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Bulletin of the Imperial Institute.

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THE IMPERIAL INSTITUTE.

The Imperial Institute was founded as the National Memorial of the Jubilee of Queen Victoria, by whom it was opened in May, 1893. The principal object of the Institute is to promote the utilisation of the commercial and industrial resources of the Empire by arranging comprehensive exhibitions of natural products, especially of India and the Colonies, and providing for the collection and dissemination of scientific, technical and commercial information relating to them. Until the end of 1902, the Imperial Institute was managed by a Governing Body, of which the Prince of Wales was President, and an Executive Council, including representatives of the Indian Empire and of all the British Colonies and Dependencies. In 1900, the building became the property of H.M. Government, by whom the western portion and galleries were leased to the Governing Body of the Imperial Institute, the greater part of the eastern and central portions being assigned to the use of the University of London. In July, 1902, an Act of Parliament was passed transferring the management of the Imperial Institute to the Board of Trade, assisted by an Advisory Committee including representatives of India and the Colonies, as well as of the India and Colonial Offices, the Board of Agriculture, and the Board of Trade. This Act took effect on January 1st, 1903.

In accordance with the above Act, the Imperial Institute is now managed by the Board of Trade in consultation with the Advisory Committee, through their Commercial, Labour, and Statistical Department, of which Mr. H. Llewellyn Smith, C.B., is Comptroller-General.

The Board of Trade have appointed Professor Wyndham Dunstan, F.R.S., hitherto Director of the Scientific and Technical Department, to be Director of the Imperial Institute at South Kensington, with charge of the various branches of work there carried on.

The work hitherto carried on by the Imperial Institute at South Kensington and in the City for the supply of general commercial, statistical and tariff intelligence is now conducted by the Commercial Intelligence Branch of the Board of Trade, which, subject to the Comptroller-General, is under the direction of Mr. Thomas Worthington. (See statement as to the work of the Commercial Intelligence Branch published in the "Board of Trade Journal.")

The entrance to the offices and library of the Imperial Institute is at the West (Queen's Gate) end of Imperial Institute Road, South Kensington. This gives access to the principal floor, containing the general enquiry office, library, reading rooms and the colonial conference rooms.

The first floor contains the General offices, the Reference Sample Room of the Scientific and Technical Department, the offices of the British Women's Emigration Association, and of the Colonial Nursing Association.

The second floor is entirely devoted to the laboratories of the Scientific and Technical Department.

The public entrances to the Indian and Colonial collections are at the East (Prince's Gate) end and the West (Queen's Gate) end of the Imperial Institute Road.

The Imperial Institute works in co-operation with the Commercial Intelligence Branch of the Board of Trade at Whitehall, with an enquiry office in the City (49, Eastcheap, E.C.) under the management of this Branch, and with the Emigrants' Information Office in Westminster.

The headquarters of the Commercial Intelligence Branch of the Board of Trade are about to be transferred to City premises (Portland House, Basinghall Street), in which the present temporary Enquiry office will be absorbed.

Indian and Colonial Economic Collections.—The Collections of economic products illustrative of the commercial resources of India and the Colonies are arranged on a geographical system in the galleries of the Institute.

Special Curators are appointed by the Governments of India, Canada, and the Cape; whilst the operations of the Indian Section are supervised by a committee appointed by the India Office.

The Collections are open free to the public daily, except on Sundays, from 11 a.m. till dusk.

It is intended, in consultation with the Governments concerned, to re-arrange and make extensive additions to many of these collections, and this work is in progress.

The following British Colonies and Dependencies are represented by collections of their products:—

BRITISH AFRICA.

Cape Colony.
Natal.
Rhodesia.
British Central Africa.
East and West African Settlements.
Mauritius.
Seychelles.

BRITISH AUSTRALASIA.

New South Wales.
Victoria.
South Australia.
Western Australia.
Queensland.
Tasmania.
New Zealand.
Fiji.

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BRITISH AMERICA.

Dominion of Canada.
Newfoundland.
Bermuda.
Bahamas.
Jamaica.
Barbados.
The Leeward Islands.
The Windward Islands
Trinidad and Tobago.
British Guiana.
British Honduras

BRITISH INDIA AND THE EAST.

India.
Ceylon.
Straits Settlements and Federated Malay States.
Hong Kong.
British North Borneo.

OTHER BRITISH POSSESSIONS.

Malta.
Falkland Islands.

Information concerning India and the Colonies, their commercial products, industries, trade, prospects for emigration, &c., may be obtained on application to the Curators for India and Ceylon, Canada and Cape Colony, at their offices in the Sections, at the Central Stand in the Galleries, at the General Enquiry Office, or enquiries may be addressed in writing to the Director of the Imperial Institute, South Kensington, S.W.

The Scientific and Technical Department.—The laboratories of this Department, which occupy the second floor of the Imperial Institute, were established chiefly with the aid of grants from the Royal Commission of the 1851 Exhibition, in order to provide for the investigation of new or little-known natural products from India and the Colonies and of known products from new sources, with a view to their utilisation in commerce, and also to provide trustworthy scientific and technical advice on matters connected with the trade and industries of India and the Colonies.

The work of the Department is chiefly initiated by the Governments of India and by Departments of the home Government and the Colonies. Arrangements have been also made by the Foreign Office, whereby British Consuls may transmit to the Department for investigation, such natural products of the countries in which they are appointed to reside as are likely to be of use to British manufacturers and merchants.

Materials are first chemically investigated in the laboratories of the Department, which has a staff of skilled assistants, and are afterwards submitted to technical trials by experts attached to the Department and finally are commercially valued.

Except under special circumstances investigations are not undertaken for private individuals.

A few illustrations of the work of the Department may be given here.

(*a*) The examination of Indian plants likely to be suitable as tanning agents, pointed to the conclusion that several would probably be useful to European tanners. One of these (*Cæsalpinia* *digyna*) was submitted to complete chemical investigation with very promising results. Tanning trials were next made on the large scale by one of the tanning experts attached to this Department, whose results confirmed the conclusion that a valuable tanning agent had been found. On the publication of the report on the subject, which was widely noticed in technical journals, a demand almost at once arose for the material in England, on the Continent, and in America, and the authorities in India are now arranging for the commercial supply.

(*b*) A plant abundant in India (*Podophyllum Emodi*) was found on chemical investigation in the Department to furnish the same constituents as the well-known drug of American origin, *Podophyllum peltatum*. The co-operation of physicians at St. Thomas's Hospital was secured, and preparations of the plant were extensively tried as a drug and found to be as valuable as those made from the American plant. A considerable demand now exists for the plant, which has been officially recognised by the Indian Medical Department, and arrangements are being made in India for a regular commercial supply.

(*c*) The same practical result has followed from the chemical investigation of a plant abundant in the Egyptian desert (*Hyoscyamus muticus*) for which a commercial demand as a drug has also arisen.

(*d*) The quality of the entire series of Indian coals has been experimentally ascertained. These represented the principal coal-seams of India, and the report has been in large request both in this country and in India. It has now been issued as an official paper by the India Office.

(*e*) The cause of the poisonous effects produced, at certain stages of their growth, on horses and cattle by certain food grains and fodder plants of India and the Colonies has been investigated, and the nature of the poison and the conditions of its occurrence determined.

(*f*) The chemical composition of india-rubber of various kinds derived from the Colonies which do not at present share in this trade, has been determined experimentally, and on the basis of these results commercial valuations have been obtained, and in some instances sales of consignments of the material have been effected.

(*g*) Collections of minerals from British Central Africa, from Somaliland, and from Northern and Southern Nigeria have been chemically examined. In certain cases where it seemed desirable, minerals have been subjected to technical trial on the large scale by manufacturers, and commercial quotations for the products obtained. Arrangements have also been made, through this

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Department, for the working of mineral deposits in the Colonies by English firms.

(*h*) The quality of leather tanned in several of the Colonies has been experimentally investigated, and with the aid of experts its suitability for the English market has been ascertained and suggestions made for its improvement.

(*i*) The chemical composition of certain oil-yielding nuts sent by British Consuls in Brazil and Portuguese South Africa, and from British Honduras, Fiji, and the Straits Settlements, has been investigated and their properties brought under the notice of British manufacturers and merchants. In several cases a considerable trade in these products has been brought about as the result of these investigations.

(*j*) Scientific and technical information has been supplied as to the curing of tobacco (Bermuda, British Central Africa, Rhodesia, and Assam), the working of mica deposits (Somaliland, India, and Southern Nigeria), the suitability of iron ores for smelting (India, British Central Africa, and Rhodesia), the production of wood-pulp (Natal), the cultivation of Indian hemp, the utilisation of tanning materials (India and West African Colonies), the collection of gums and resins (Uganda and India), the distillation of essential oils (Fiji), and many similar subjects.

It will be seen that the results of the work of the Department are often of as much importance to British manufacturers as to the trade of the Colonies concerned.

A large room on the first floor, which formerly contained the library, is now occupied by a reference collection of samples of economic products, derived chiefly from India and the Colonies, which have been investigated and reported on by the Scientific and Technical Department, and as to which full information is available.

The principal Technical Reports and Scientific Papers which have emanated from this Department since it was fully established in 1896 have now been published in a single volume, which may be purchased at the Central Stand, or on application by letter to the Director of the Imperial Institute (price 15*s*.).

Library and Reading Rooms.—The library and reading rooms of the Imperial Institute have been entirely re-arranged. They contain a large collection of Indian and Colonial works of reference, and are regularly supplied with the principal official publications of India and the Colonies, and with many of the principal newspapers and periodicals of the United Kingdom, India, and the Colonies. The library also contains a collection of Indian and Colonial maps and charts.

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The library and reading rooms are on the principal floor, and are entered through the entrance at the west (Queen's Gate) end of the building. These rooms are available for the use of Life Fellows of the Imperial Institute, and of persons introduced by them.

Colonial Conference Rooms.—Three large rooms, specially decorated and furnished, are reserved on the principal floor for use by representatives of the Colonies for meetings and receptions.

The Cowasjee Jehanghier Hall.—The rooms in connection with this Hall are in the occupation of the Indian Committee of the Imperial Institute, whilst the Imperial Institute, the India Office and the London University have the right of using the Hall for lectures, meetings, &c.

Unofficial Societies occupying rooms in the Imperial Institute:—

(*a*) **British Women's Emigration Association.**—The British Women's Emigration Association has been assigned an office on the first floor, which is open daily from 10 a.m. to 4 p.m., and advice and information respecting emigration and the prospects for women in the Colonies may be obtained there free of charge. This Association works in co-operation with the Emigrants' Information Office in Westminster.

(*b*) **Colonial Nursing Association.**—This Association has been assigned an office on the first floor of the Imperial Institute (Room 5). Its principal object is the selection of trained hospital and private nurses for the Crown Colonies and other British Dependencies.

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The Imperial Institute.

LIBRARY.—RECENT ADDITIONS.

Books and Publications, exclusive of Government Publications, presented by Publishers and Others to the Library of the Imperial Institute since 31*st December*, 1903.

Gold Coast Native Institutions	By C. Hayford.	(*Messrs. Sweet & Maxwell*).
Somaliland	By C. V. A. Peel.	(*Messrs. Robinson & Co.*).
St. Helena	By E. L. Jackson.	(*Messrs. Ward, Lock & Co.*).
New Africa	By E. Descamps.	(*Messrs. Low, Marston & Co.*).
Nova Scotia and the Bay of Funday	J. D. Potter.	(*Messrs. Eyre & Spottiswoode.*)
Directory of the Chief Industries of India		(*Messrs. Thacker & Co.*).
Basutoland	By M. Martin.	(*Messrs. Nichols & Co.*).
Standard Fungicides and Insecticides	By G. F. Strawson.	(*Messrs. Spottiswoode & Co.*).
Progress of the British Empire in the Century	By J. S. Little.	
Commercial Geography of the World, Outside the British Isles	By A. G. Herbertson.	(*Messrs. Chambers & Co.*).
From Adam's Peak to Elephanta	By E. Carpenter.	(*Messrs. S. Sonnenschein & Co.*).
Trade and Travel in South America	By F. Alcock.	(*Messrs. G. Philip & Sons.*).
Sewage and Sewage Purification	By S. Rideal.	(*Sanitary Publishing Co.*).
Australind	By H. Taunton.	(*Edward Arnold*).
The Native Problem	By A. Davis.	(*Messrs. Chapman & Hall*).
Outlines of Geology	By J. Geikie.	(*Edward Stanford*).
Nyasaland under the Foreign Office	By H. L. Duff.	(*Messrs. G. Bell & Sons*).

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Imperial Fellowship of Self-Governed British Colonies	By Lord Norton. (*Messrs. Rivington & Co.*).
The International Geography	By H. R. Mill. (*Messrs. G. Newnes & Co.*).
Metallurgical Analysis and Assaying ...	By W. A. Macleod and Charles Walker. (*Messrs. G. Griffin & Co.*).
A Review of Mineral Systems	By the late Dr. E. J. Chapman.
Index to the Transactions of the Institution of Naval Architects. Vols. I.–XLII.	(*Secretary of the Institute.*)
Chemical Manufacturers' Directory of England and Wales for 1904.	(*The Editor.*)
Proceedings of the Royal Geographical Society of Australasia; South Australian Branch. Vol. VI.	(*The Secretary.*)
Transactions of the Royal Scottish Society of Arts for 1903	(*The Secretary.*)
Queensland Geographical Journal, 1902-3	(*Queensland Geographical Society.*)
Report of the Smithsonian Institution (United States) for the year 1902 ...	(*The Secretary.*)
The Jubilee Volume of the Chamber of Commerce and Industries, Zegreb, Austria	(*The Secretary.*)
The Paper Mills Directory for 1904 ...	(*The Editor.*)

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INDIAN AND COLONIAL COLLECTIONS.

NOTES ON RECENT ADDITIONS.

Central Stand for Publications and Enquiries.—A stand has been opened in the centre of the main gallery to facilitate the answering of enquiries and the distribution of literature. Pamphlets, circulars, handbooks, &c., containing information relating to the commerce, agriculture, mining and other industries of the principal British Colonies, and also to emigration, may be obtained gratuitously. Certain publications are for sale. (See lists on cover.) The publications of the Emigrants' Information Office, established by the Colonial Office, may also be obtained. The principal Indian and Colonial newspapers may be seen on application.

An officer of the Institute is in attendance at this stand, which is in telephonic communication with the offices of the Curators and with the General offices in the main building.

India.—A large number of the exhibits in this section have been re-arranged. Preliminary lists of "edible substances," "oil-seeds and oils," "gums and resins," and "dyes and tans," have already been printed, and copies can be obtained gratis on application to the Curator of the Indian section, or at the Central stand.

An interesting collection of textile fabrics illustrating the use of wax, either for ornamental printing in relief on a coloured ground, or as a "resist" for protecting certain portions of a design from the action of dyes, has been arranged in the Indian section. A collection of samples of textile fabrics, including tweeds, serges, drills, twills, sheeting, towelling, &c., contributed by Bombay and Madras manufacturers is exhibited in the East Gallery.

Canada.—A comprehensive collection illustrative of the economic minerals of British Columbia, and also an exhibit of furniture and carriages entirely manufactured in Canada of Canadian woods are shown in the western end of the North Gallery. A new collection of specimens illustrating the cereal resources of British Columbia has been added to the section.

Straits Settlements and Federated Malay States.—Considerable progress has been made in the re-organisation of this Court, on a plan prepared last year by Professor Dunstan, which was approved by the Government of the Straits Settlements, by whom the work of collecting and preparing in the Colony the new exhibits required, was entrusted to Mr. H. N. Ridley, M.A., Director of Botanic Gardens and Forests at Singapore. Much assistance has kindly been given by Mr. Leonard Wray, F.Z.S., Curator of the Government Museum at Perak, whilst on leave in this country.

The Straits Court is being re-modelled in accordance with the

Notes on Recent Additions.

general scheme for the improvement of the Collections, the object in view being to render the exhibits of greater value to commercial men, for educational purposes, and as a means of bringing to public notice recent developments in economic research. To this end the specimens have been thoroughly overhauled and a representative series selected for exhibition. Temporary labels have been added giving information describing the collection and manufacture of important products, and the local uses of other products, many of which do not appear as exports. These temporary labels are being replaced as rapidly as possible by fuller, specially prepared, printed labels, and when this work is completed it will be possible for the visitor to learn, as completely as the specimens allow, the method of cultivation, collection and manufacture of the products, and the uses to which they are put.

The tin industry has received special treatment in view of its paramount importance, and a complete series of specimens and photographs, illustrating the modes of occurrence of the tin ores, the methods of mining and smelting, have been placed on exhibition with full descriptive labels. Specimens illustrating the application of tin to the native manufacture of articles of every-day use, such as bowls, tobacco boxes and trays, have been received recently from Singapore, and will shortly be placed on exhibition in the Court.

The geology of the peninsula is illustrated by a set of specimens with notes on the occurrence, geological age, and economic importance of the several formations.

Rice, sago, sugar, rattan canes, gutta-percha, rubbers, dammar resins, fibres, gambier and other tanning materials, dye stuffs, spices, &c., are similarly represented by selected specimens and descriptions of their collection, manufacture and uses.

Statistical tables showing the area, population, revenue, expenditure, trade and exports, prepared by the local Government, have been placed in the Court.

An important addition is a large map specially prepared for the Court, showing the several Settlements and States under British administration, the railways, and other features of interest.

When the new exhibits arrive and have been incorporated in the present collection the Court will give a full and accurate representation of the economic resources of the Straits Settlements and Federated Malay States, and prove an important factor in extending public knowledge of the country and furthering its commercial interests.

British North Borneo.—A collection of the commercial products of British North Borneo, including timbers, coal, rice, sago, sugar, coffee, cacao, pepper, tobacco and cigars, camphor, gutta-percha, dammar, resins, cutch and gambier, is on view in the North Gallery.

Notes on Recent Additions.

Western Australia.—Furniture manufactured from the principal hard woods of the State, chiefly Jarrah and Karri, illustrating the adaptability of these woods for mouldings and turned work, as well as their susceptibility of taking a high polish and finish, is shown in the North Gallery.

Queensland.—A collection of the more important products of Queensland, especially minerals, and a large number of photographs is shown in the North Gallery.

New South Wales.—A small accessory collection of hardwood paving blocks is on view in this Court; some of the specimens have been subjected to several years' traffic in Sydney. The three varieties shown are " black-butt," "brush box," and "tallow-wood." A map indicating the distribution of the more important timber trees in New South Wales and Victoria has also been added to this section.

Hong Kong—The exhibits in this section have been re-arranged. Two wall cases have been added showing specimens of pewter, lacquer ware, earthenware and china.

British Central Africa Protectorate.—The collection illustrating the resources of British Central Africa, situated at the west end of the Central Gallery, has been re-arranged and labelled. The principal products of the Protectorate are represented; foremost amongst these being coffee, which has recently become the chief article of export, and of which some good samples from the Shiré Highlands are shown. There are also exhibits of rubber in the form in which it is brought in by natives, and of strophanthus seeds, a characteristic product of tropical Africa, formerly used as an arrow poison but now exported in considerable quantity to European countries for use in medicine. A detailed description of these exhibits was given in the " Imperial Institute Bulletin," Vol. I., page 12.

Zanzibar and Pemba.—Progress is being made with the re-arrangement of the exhibits in this section. The collection, which is located at the west end of the Central Gallery, contains samples of the clothing worn by the natives, soap, washing blue, and specimens of agricultural implements: the local produce is represented by samples of cloves, chillies and copra. The remainder of the exhibit illustrates the trade which is carried on between Zanzibar and the mainland. Statistical information concerning the trade of the islands is supplied, and the new labels explain the nature of the various articles which are displayed. For a fuller account see special article (p. 12).

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NOTES ON THE ZANZIBAR AND PEMBA COLLECTIONS OF THE IMPERIAL INSTITUTE.

The specimens included in the collections of Zanzibar and Pemba fall into three categories. There is the produce of the island, of which the most important items are cloves, copra, and chillies. The export of cloves amounted to 4,500 tons in the year 1902, despite the fact that the crop that year was the lowest during the previous decade. The bulk of this commodity is exported to British India, but Holland and Great Britain also take a considerable proportion. A number of the exhibits come under the head of "goods in transit." These are raw materials, including rubber, hides, and ivory, which are transported from the mainland to Zanzibar to be transhipped to manufacturing countries. Similarly, a portion of the manufactured goods required by the natives on the mainland passes through the ports in the islands of Zanzibar and Pemba, which serve as distributing centres. With the construction of the Uganda railway Mombasa has entered into competition with these islands as a distributing centre.

The third series of specimens is intended to furnish an indication of the requirements of the natives in the matter of dress, washing requisites, and agricultural implements. The articles included under piece-goods are "kanzus"—white cotton garments which reach from neck to heel—cotton vests, loin cloths, or "vikoi," felt caps, and the cotton material, dyed indigo blue, known as "kaniki."

A number of the products of Pemba and Zanzibar have been examined and reported on by the Scientific and Technical Department of the Imperial Institute. These include specimens of rice, tanning materials, and dye stuffs, &c., and an account of these will be published shortly.

SCIENTIFIC AND TECHNICAL DEPARTMENT.

COTTON GROWING IN SOUTHERN NIGERIA.

An important step has been taken by the Colonial Office, in conjunction with the Board of Trade, in giving expert assistance from the Imperial Institute to a project of the British Cotton Growing Association to start cotton growing on a large scale in Southern Nigeria. A detailed examination is to be made of several promising districts in the Protectorate in order to determine the suitability of the soil, climate, &c., for planting cotton, the most important of these districts being the Sobo Plains, near the coast, where the Ethiope and Jamieson Rivers enter the sea.

In accordance with arrangements made between the Colonial Office and the Board of Trade, Mr. W. G. Freeman B.Sc., of the Scientific staff of the Imperial Institute, formerly of the Department of Agriculture of the West Indies, has just left England to co-operate in this matter with Mr. P Hitchens, a local Forestry Officer in Southern Nigeria, whose services have been placed at the disposal of the British Cotton Growing Association by the Local Government

I.—REPORTS ON RECENT INVESTIGATIONS.

OCCURRENCE OF THORIUM IN CEYLON.

In connection with the Mineral Survey now proceeding in Ceylon in conjunction with the Scientific and Technical Department of the Imperial Institute, specimens of minerals supposed to be monazite and uraninite have been sent recently to the Imperial Institute for investigation. The first of these has proved on analysis not to be monazite but thorite, which is a silicate of thorium, containing over 66 per cent. of thorium oxide. The supposed uraninite has proved to be a new mineral which it is proposed to name *thorianite*. It contains 75 per cent. of thorium oxide (thoria) in addition to small quantities of the oxides of cerium, uranium, and lead. Thorianite is therefore richer in thorium than any mineral at present known.

These discoveries in Ceylon of minerals containing thorium may be of great importance to the Colony if the deposits prove to be extensive, since thoria is largely employed in the manufacture of incandescent gas-mantles. Additional interest attaches to the mineral thorianite, which is strongly radio-active, and may prove to be a source of radium.

The Imperial Institute expects shortly to receive further specimens and information as to the occurrence of these minerals in Ceylon.

GUTTA-PERCHAS FROM THE STRAITS SETTLEMENTS.

These samples of gutta-perchas were forwarded from Penang for the purpose of ascertaining their chemical composition and commercial value.

The specimens received were as follows:—

1. Sample of gutta-percha and about 50 lb. of dried leaves of the species of Palaquium (*Palaquium pustulatum*?) known in the State of Perak as "Gutta Taban Putih."
2. Sample of "Gutta Simpor" (*Palaquium Maingayi*).
3. Sample of "Gutta Taban Chaia" (*Palaquium polyanthum*?).
4. Sample of "Gutta Minjato" (*Bassia sp.*?) from Langkawi Islands.
5. Sample of "Gutta Susu" (*Dyera sp.*) from Langkawi Islands.
6. "Gutta Taban Merah" (*Palaquium Gutta*) from Penang forests.

The specimens Nos. 1, 2, 3 and 6 were collected under the supervision of European forest officers in order to ensure their authenticity, and they therefore represent the products of the different species of Palaquium without any admixture whatsoever.

Information was particularly desired concerning specimens Nos. 1 to 5, and of these, No. 1, Gutta Taban Putih, was stated to be the most important. This gutta is derived from a tree, probably *Palaquium pustulatum*, though the species is a little uncertain at present, which is the most abundant of the Palaquiums in the State of Perak, as it will grow at elevations of over 2,000 feet. If the gutta-percha yielded by this species proved to be of good quality it was proposed to establish extensive plantations of the trees.

Numerous proposals have been made during recent years to extract the gutta-percha from the leaves of the Palaquiums, thereby obtaining an earlier yield from the plantations than would be possible otherwise. A large sample of the dried leaves of the tree yielding the Gutta Taban Putih was forwarded, therefore, so that experiments could be made to determine the amount and quality of the gutta-percha contained in them, and the feasibility of extracting it upon a commercial scale.

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Description of the samples.

No. 1. Gutta Tabân Putih, from *Palaquium pustulatum*?

The specimen was a conical mass which possessed a curious colour externally, varying from brown to bluish-black, but when freshly cut it was almost white within. It was hard, very tenacious, and contained very little foreign matter. On immersion in hot water it softened, becoming plastic, but not sticky, and could be readily moulded, after which treatment it returned to its original condition on standing.

No. 2. Gutta Simpor, from *Palaquium Maingayi*. This was a rounded cake, light brown externally, but whitish within, which had a distinct cinnamon odour, and contained a small amount of foreign vegetable matter. It was hard in the mass, but the inner portions were easily friable, whereas the outer layers were tougher and somewhat laminated; the greater part of the sample was easily reduced to coarse powder in a mortar. It became plastic, but not sticky, when immersed in hot water, and the water acquired a slight yellow colour. After this treatment it hardened somewhat on standing, but exhibited little tenacity, readily breaking when bent.

No. 3. Gutta Taban Chaia, from *Palaquium polyanthum*?

The specimen was a small rounded mass, which was brown externally but much lighter within, and contained a small quantity of vegetable matter. It was hard in the mass, and exhibited considerable tenacity; small pieces were slightly elastic, and softened a little when held in the hand. When placed in hot water it behaved exactly like the preceding specimen, but exhibited much greater tenacity after cooling.

No. 4. Gutta Minjato, from *Bassia sp.*? From the Langkawi Islands.

The sample was a rectangular cake, dark brown externally, but light brown within, which exhibited a laminated appearance when cut, and contained a slight amount of vegetable matter. It was hard in the mass, but fragments were easily friable, and it could be reduced to coarse powder in a mortar. When treated with hot water it formed a very soft, sticky mass, and communicated a slight yellow colour to the water. After this treatment it remained flexible for some time, but finally became hard and brittle, breaking readily with a short fracture.

No. 5. Gutta Susu, from *Dyera sp.* From the Langkawi Islands.

This was a flat rounded cake, dirty white externally, but quite white within, and almost entirely free from extraneous vegetable matter. It is probably identical with commercial "Pontianac"

Gutta Percha from the Straits Settlements.

(see Imperial Institute Bulletin, Vol. I., p. 65), which it closely resembles in appearance. The sample was fairly hard in the mass, but small pieces could be moulded in the fingers, becoming slightly sticky. On immersion in hot water it softened, becoming quite plastic and rather sticky, and only hardened a little on standing.

No. 6. Gutta Taban Merah, from *Palaquium Gutta.* From Penang forests.

This was a rounded mass which presented a mottled appearance, the colour varying from light brown to nearly white. A fair amount of vegetable matter was present, chiefly small pieces of bark. The material was very hard and tenacious. It softened in hot water, becoming quite plastic, but not at all sticky, and regained its original condition on standing.

Chemical Examination.

The samples were submitted to chemical examination in the Scientific and Technical Department of the Imperial Institute, and the following results were obtained :—

No.	Variety of Gutta Percha. Native Name and Botanical Source.	Moisture.	Gutta.	Resin.	'Dirt' and Insoluble Matter.	Ash (included in dirt).	Character of Gutta.	Character of Resin.
		Per cent	Per cent	Per cent	Per cent	Per cent		
1	Gutta Taban Putih *Palaquium pustulatum ?*	7·5	35·6	49·5	7·4	0·72	Light brown, strong	White, hard.
2	Gutta Simpor ... *Palaquium Maingayi*	1·2	44·9	45·5	8·4	2·13	" "	" "
3	Gutta Taban Chaia *Palaquium polyanthum ?*	1·2	52·0	43·4	3·4	1·61	Light brown, rather better quality than Nos. 1 and 2.	Yellowish-brown, hard and translucent.
4	Gutta Minjato ... *Bassia sp. ?*	2·6	22·4	70·1	4·9	0·66	Light brown, friable and somewhat waxy.	Yellowish-brown, hard and translucent.
5	Gutta Susu ... *Dyera sp.*	19·5	1·9	69·8	8·8	0·71	Contained no gutta.	White, soft.
6	Gutta Taban Merah *Palaquium Gutta*	10·2	68·3	13·4	8·1	0·89	Light colour, strong, excellent quality.	Yellowish-white, soft.

Gutta-Percha from the Settle-

For comparison, the percentages of gutta, resin and dirt have been calculated for the dry material as follows:—

—	No. 1. Gutta Taban Putih.	No. 2. Gutta Simpor.	No. 3. Gutta Taban Chaia.	No. 4. Gutta Minjato	No. 5. Gutta Susu.	No. 6. Gutta Taban Merah.
Gutta	38·5	45·5	52·6	23·0	2·4	76·0
Resin	53·5	46·0	44·0	72·0	86·7	15·0
Dirt and insoluble matter..	8·0	8·5	3 4	5·0	10·9	9·0
Ash (included in dirt) ...	0·77	2·16	1·64	0·7	0·9	1·0

These results show that the sample of Gutta Taban Merah, No. 6, which represents the highest class of gutta-percha, is of excellent quality, and far superior to any of the other specimens. The Gutta Taban Putih, No. 1, contains a much higher percentage of resin, and is, therefore, very inferior in quality to the preceding; the gutta which it contains is strong, and of good quality however Gutta Simpor, No. 2, is also an inferior grade of gutta-percha, owing to the presence of much resin, but here again the actual gutta is of good quality. The Gutta Taban Chaia, No. 3, is a very similar material to Nos. 1 and 2, but contains a little less resin, and its gutta is of rather better quality. The Gutta Minjato, No. 4, and Gutta Susu, No. 5, are not true gutta-perchas, since they contain no proper gutta. The "gutta" obtained from No. 4 was a friable and somewhat waxy substance, possessing little or no strength, whilst No. 5, which resembles Pontianac, contained no gutta, but a quantity of rubber-like material, which was completely dissolved with the resin on treatment with ether. Neither of these samples could be utilised for insulating purposes.

For comparison with the foregoing results, some analyses by Dr. Obach of similar samples of gutta-perchas of known botanical origin may be quoted (see Journal of the Society of Arts, Vol. XLVI., pp. 125 and 127).

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Specimens of Gutta-percha collected in Perak by Mr. Leonard Wray, jun., and presented to the Royal Botanic Gardens, Kew, in 1883–4. (Analysed in 1885.)

Variety of Gutta-percha. Native Name.	Botanical Source given by Mr. Wray.	Appearance.	Water.	Gutta.	Resin.	Dirt.	Character of Gutta.	Character of Resin.
			Per cent.	Per cent.	Per cent.	Per cent.		
Getah Taban Puteh (white)	*Dichopsis polyantha* (Benth.)	White, clean ...	1·0	47·0	48·4	3·6	Light brown, elastic	Light brown, brittle
Getah Taban Simpor ...	*Dichopsis Maingayi* (Clarke)	Nearly white, clean, crumbly	1·2	23·1	71·5	4·2	Light pinkish-brown, elastic	Very light, hard
Getah Taban Chaier (liquid)	*Dichopsis pustulata* (Helmsley)	White, dense, clean	1·7	45·3	49·6	3·4	Light brown, elastic	Light brown, very brittle
Getah Taban Merah (red)	*Dichopsis Gutta* (Benth. and Hook.)	Very light, pinkish, clean	1·4	77·1	16·9	4·6	Light pinkish, elastic, prime	Brownish yellow, very hard

A second and larger sample of Getah Taban Simpor from *Dichopsis Maingayi* was sent to Kew by Mr. Wray in 1886. On analysis this was found to contain 31·2 per cent. of gutta and 62·3 per cent. of resin, and was, therefore, of better quality than the first specimen.

Specimen of Gutta-percha obtained by Dr. Obach from Mr. H. N. Ridley in 1892.

Getah Taban Merah ...	*Dichopsis Gutta* (Benth.)	Light pinkish-brown, clean, dense	16·1	66·7	14·0	6·2	Light pinkish, very strong	Hard, reddish brown, translucent

Gutta Percha from the Straits Settlements.

The results of the chemical examination of the present series of samples are in general agreement with the previous analyses just given. The sample of Gutta Taban Putih analysed by Dr. Obach was of rather better quality than that now under notice, whereas the present samples of Gutta Simpor and Gutta Taban Chaia are distinctly better than the earlier specimens. It will be noticed that the botanical sources of Gutta Taban Putih and Gutta Taban Chaia are transposed in the two series.

Commercial Valuation.

The samples were submitted for valuation and technical trial to manufacturers using large quantities of gutta-percha, who reported that, as the result of their examination, they valued the specimens as follows:—

No. 1, Gutta Taban Putih, 2*s.* per lb.
No. 2, Gutta Simpor, 1*s* 6*d.* per lb.
No. 3, Gutta Taban Chaia, 2*s.* 4*d.* per lb.
No. 4, Gutta Minjato, no use for insulating purposes.
No 5, Gutta Susu, no use for insulating purposes.
No. 6, Gutta Taban Merah, 6*s.* per lb.

The price of the last sample may be taken to represent the market value of the highest grade of gutta-percha, subject to fluctuations, and it is evident, therefore, that Gutta Taban Putih of similar quality to the present specimen will only command one-third the price of this. It will be noticed, too, that a higher value is assigned to the Gutta Taban Chaia than to the Gutta Taban Putih. The Gutta Susu would fetch the market price of Pontianac.

Conclusions.

This enquiry has shown, therefore, that the Gutta Taban Putih is very inferior in quality to the Gutta Taban Merah, and that it is only worth about one-third the price of the latter. No information has been furnished regarding the relative yields of gutta-percha obtained from the two trees in these experiments, but previous investigations upon this point seem to indicate that there is no great difference in this respect between the two species. If this be so, the establishment of extensive plantations of the trees yielding Gutta Taban Putih could not be recommended in any locality where the much more valuable Taban Merah trees can be successfully grown, as there can be no doubt that the latter would give the best financial results. If the Taban Putih trees can be grown at higher altitudes than the other species, it would probably be advantageous to establish supplementary plantations of them in suitable districts. The trees yielding Gutta Taban Chaia may also be worthy of further experiments if they are suitable for cultivation in any districts where Taban Merah trees cannot be grown, since the gutta-percha furnished by them appears to be slightly superior to the Gutta Taban Putih.

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Extraction of Gutta-percha from the Leaves

About 50 lb. of the dried leaves of the tree yielding Gutta Taban Putih (*Palaquium pustulatum?*) were forwarded so that experiments could be made to determine the amount of gutta-percha they contain, and the possibility of extracting it upon a commercial scale. It may be noted at the outset, however, that the examination of the gutta-perchas obtained from the trees has shown that Gutta Taban Putih is very much inferior in quality to Gutta Taban Merah, and this is also likely to be true in the case of the product from the leaves of the two trees. The problem of devising a suitable process for the extraction of gutta-percha from leaves is a difficult one, which has not yet been satisfactorily solved, and at this stage it would be desirable in any experiments upon the subject to employ the leaves of the tree furnishing the best quality of gutta-percha.

The leaves were ground to coarse powder, and were extracted in various ways by different solvents, with the result that they were found to contain about 2 per cent. of pure gutta, together with a large amount of resinous substances. The gutta thus obtained exhibited very good physical properties. The sample of Gutta Taban Putih derived from the tree contained only 35·6 per cent. of pure gutta, so that the above yield of gutta would indicate that the leaves contain 5·6 per cent. of gutta-percha of similar quality to that yielded by the tree.

It is very probable, however, that the yield of gutta-percha obtained from dry leaves in Europe is much lower than would be obtained from the same leaves by treatment in the Straits Settlements. The gutta-percha in the leaves is in a very finely-divided condition, and is, therefore, extremely liable to oxidation, with the formation of resinous substances, so that owing to changes during transport, the quantity of gutta is likely to be considerably reduced. According to published statements on the subject, 9 or 10 per cent. of gutta-percha can be obtained from the leaves by extraction with solvents when the process is carried out on the spot.

The possibility of extracting gutta-percha from the leaves has been the subject of many investigations during recent years, and numerous processes, many of which are protected by patents, have been already devised for the purpose. Most of these depend upon the extraction of the gutta-percha by means of solvents, but others have been suggested in which the gutta-percha is obtained by mechanical treatment. Several of the extraction processes have been tried upon a commercial scale in Europe, but for various reasons the results have been very unsatisfactory from a financial point of view, and it is believed that at the present time all the factories established in Europe have practically suspended operations.

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It would appear from the results of these trials, that in order to make any process a success it will be necessary to work it on the spot, and that further experiments are required to determine the particular method most suited to the local conditions. Many of the processes which have been suggested involve the use of solvents of low boiling points, and would be very difficult to carry out in the tropics upon a large scale. From this point of view a mechanical process would be much preferable if one giving satisfactory results could be devised. It has been stated that the quality of the gutta-percha obtained by mechanical methods is better than that prepared by the use of solvents, but the yield is said to be very much less. It would be well if this latter point could be definitely settled, and experiments might be made to determine whether the yield could not be greatly increased by suitable treatment. A process depending upon the digestion and agitation of the crushed leaves with hot water in suitable machines may be suggested as one deserving experimental trial. The gutta-percha in fresh leaves could possibly be readily separated by such treatment, and could be easily washed free from vegetable impurities. Machinery has been designed for extracting rubber from bark in this way, and is at present being used in the French Congo for the preparation of "root-rubber." If such a process, suitably modified, could be used for extracting gutta-percha from leaves, it would probably be preferable to and cheaper than any method involving the use of solvents.

It is understood that several processes are at present undergoing practical trials in the East, and the results of these will afford some indication of their suitability for general use, and the possibility of their proving a financial success. It would probably be desirable to await the results of these trials before commencing operations upon a large scale in the Straits Settlements, and in the meantime to carry out some experiments upon mechanical processes as suggested above.

Another point which arises in connection with this subject is the possibility of obtaining regularly a sufficient supply of leaves to make the industry remunerative. It seems probable that, whatever process be adopted, it could only be successfully worked in connection with extensive plantations of the trees, and even then it may be doubted whether it would be advantageous to pluck leaves from cultivated trees for the purpose of extracting the gutta-percha from them. This point, however, must be left for the consideration of the local authorities.

In view of the great superiority of Gutta Taban Merah over the other varieties of gutta-percha, it would be desirable, in any further experiments upon this subject, to use the leaves of that tree, as they would in all probability furnish the best results.

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THE COMMERCIAL UTILISATION OF THE SEEDS OF THE PARA RUBBER TREE (*HEVEA BRASILIENSIS*).

The report on this subject which appeared in this Bulletin (1903, Vol. I., p. 156), giving a preliminary account of the results of a chemical investigation of the seeds carried out in the Scientific and Technical Department of the Imperial Institute, has attracted considerable attention from planters and others interested in the cultivation and production of Para rubber. It may, therefore, be useful to give some additional information regarding the oil and other products obtainable from these seeds.

Para Rubber Seed Oil.—This material possesses properties very similar to those of linseed oil, and should therefore be suitable for the preparation of paints and oil varnishes, and for the manufacture of rubber substitutes, linoleum and waterproofing materials. It could probably also be used like linseed oil for the manufacture of soft soap, but its colour would preclude its employment for the preparation of hard soaps except in cases where there is a scarcity of cotton-seed and similar light-coloured, non-drying oils. It is intended to make further experiments regarding its applicability for manufacturing purposes.

Para Rubber Seed Cake.—As stated in the previous report, the cake left after expressing the oil from the decorticated seeds would probably be of value as a cattle food, since its calculated composition compares very favourably with the various cakes at present in use, and it is stated that animals readily eat the kernels in the Straits Settlements. The suitability of the material for this purpose is being fully investigated at the Imperial Institute.

A large consignment of the seeds has been already despatched from the Straits Settlements in order that technical trials upon a commercial scale may be conducted to determine the properties of the expressed oil, and at the same time to ascertain the value and suitability of the cake as a cattle food by analysis and by feeding trials.

A sample of Para rubber seed meal, prepared in the Straits Settlements from the seeds without separation of the oil, was also forwarded to the Imperial Institute for examination, but this material, in the form in which it was sent, was found to be unsuitable for use either as a source of the oil, which had suffered change, or as a feeding stuff. Since the meal was found to contain over 1 per cent. of phosphoric acid it might be used as a dressing for grass land, in a similar manner to

The Commercial Utilisation of the Seeds of the Para Rubber Tree.

rape meal, for which 4*l.* 10*s.* per ton is paid in this country. The sample of meal sent for examination contained, in a decomposed state, the whole of the oil originally present in the seeds, and as the valuations indicate that the probable value of the seeds as a source of oil would be at least from 10*l.* to 12*l.* per ton, their utilisation for the preparation of meal similar to the sample could not be recommended. The cake left after expression of the oil might be utilised for manurial purposes, and it was, of course, with this object in view that the amount of phosphoric acid in the meal was determined, but here again it may be found that Para rubber seed cake will be suitable for use as a cattle food, in which case it will probably be too valuable to be used as a manure.

All these questions are receiving attention in the Scientific and Technical Department of the Imperial Institute, and a further report on the subject will be issued when the experiments are completed.

THE RESIN OF *HOPEA ODORATA* FROM BURMA.

A sample of this resin was forwarded to the Imperial Institute by the Reporter on Economic Products to the Government of India, in order that it might be chemically examined and its commercial value ascertained. The resin is stated to be known in Indian commerce as "Rock Dammar," and to be especially abundant in the South Tenasserim Division of Burma, where it is procurable at the rate of 4 annas per viss, approximately equivalent to 10*s.* per cwt.

The specimen consisted of large, irregularly-shaped tears of a yellow colour, possessing a brilliant, irregular fracture, and a slight aromatic odour. The resin melted at 115° C., and yielded 0·56 per cent. of ash. Its saponification value was 37·1, acid value 31·5, and ester value 5·6. It was completely soluble in turpentine oil and partially so in alcohol.

The dammar resins of commerce are derived from a great variety of plants, and consequently present considerable variations in composition and properties, so that it is impossible to quote for comparison analytical results which can be regarded as typical of this class of resins. The principal botanical sources of the dammars are as follows:—

The Resin of Hopea Odorata from Burma.

Sumatra, or East Indian Dammar, from *Agathis loranthifolia.*
Sâl Dammar, from *Shorea robusta.*
Cat's-eye Dammar, from *Hopea micrantha.*
Rose Dammar, from *Vatica rassak.*
Selo Dammar, from *Artocarpus integrifolia.*
Black Dammar, from *Canarium strictum.*
and *Canarium rostratum* (?)

In addition to these the Kauri resin of New Zealand, furnished by *Agathis australis,* may also be regarded as a dammar.

These resins are, as a rule, hard, and exhibit brilliant fractures, are partially soluble in alcohol, and completely soluble in turpentine. Their acid values vary from 21 to 34·2 in the case of different specimens of "Sumatra dammar" to 73 for "black dammar."

The results of the chemical examination of the resin of *Hopea odorata* indicate that it may be regarded as a dammar resin, and may be classed with the better varieties. Specimens of this product were submitted to a firm of varnish makers for technical trial and commercial valuation. They reported that the resin would be classed commercially as a second quality dammar, and that it could be used for the preparation of "paper" or "crystal" varnishes such as are employed for indoor decorative work. Its value at present would be about 2*l.* 5*s.* per cwt. The demand for resins of this type is unfortunately somewhat limited, since varnishes made with them are not sufficiently durable to be used for outdoor work. The varnish makers, however, point out that if this resin could be procured in a "fossilised" form it would probably yield a varnish as durable as that obtained from Manila copal, and that, although the price obtainable for the "fossilised" resin would be somewhat less than that quoted, the demand would be practically unlimited.

GOMMIER RESIN FROM DOMINICA.

This consignment of gommier resin was forwarded by the Administrator of Dominica to the Hon. F. Watts, Government Analytical Chemist to the Leeward Islands, who was then in England, in order that the commercial value of the material might be ascertained. At Mr. Watts's suggestion the matter was referred by the Colonial Office to the Imperial Institute for investigation.

Gommier Resin from Dominica.

In the correspondence accompanying the sample it was stated that the gommier tree is of common occurrence in the forests of Dominica, and that the resin is collected by the natives and used locally for the preparation of torches and as incense. The resin exudes either from natural fissures or from cuts made in the bark; it is at first an opaque, whitish, highly viscous liquid, which soon dries into soft yellowish lumps, and eventually into hard, brittle masses of white resin, and it is in the latter form that it is usually collected. The cost of collecting the resin in Dominica is stated to be from 3*d*. to 4*d*. per lb.

Small consignments of the material have been sold in European markets from time to time, principally as a substitute for the elemi resin produced by the tree, *Canarium commune*, occurring in the Philippine Islands. On account of its general resemblance to true elemi, gommier resin is commonly known as "dry," or West Indian elemi.

The present consignment of gommier resin consisted principally of large flattened lumps of hard resin, somewhat dirty externally, but snow white internally. When examined under the microscope these lumps were found to consist almost entirely of a substance crystallising in minute needles. There was also present a small proportion of lumps of soft resin which was slightly yellow, and generally contaminated by pieces of bark, earth, small stones, etc. This soft resin was crystalline only on the surface.

The material had a pleasant aromatic odour, which was especially marked in freshly broken pieces of the softer resin.

Chemical Analysis of the Gommier Resin.

As the hard and soft resin differed materially in composition, representative specimens of each kind were selected for analysis. The results of this investigation are tabulated below, the corresponding figures for commercial specimens of elemi resin being added for comparison:—

	GOMMIER RESIN.		
	Hard.	*Soft.*	ELEMI RESIN.
Saponification value	24·7	41·6	25·72 –49·98
Acid value	14·1	37·3	17·7 –24·48
Ester value	10·6	4·3	7·64 –26·99
Ash	0·08 %	0·36 %	0·023– 0·93 %
Melting point	158°–164°	Below 100° C.	—

The hard resin is completely soluble in alcohol, and partially so in turpentine oil, whilst the soft resin is entirely soluble in turpentine oil and only partially so in alcohol.

These results indicate that the West Indian resin is probably similar to true elemi in composition, but the exact differences between the two products could only be ascertained by a complete chemical investigation of the constituents of the two resins. Preliminary experiments made in the Scientific and Technical Department of the Imperial Institute have shown that the principal constituent of the gommier resin is a white crystalline substance probably identical with one of the constituents of elemi resin.

Commercial Valuation of Gommier Resin.

The principal purposes to which elemi resin is applied are the preparation of printing inks and the manufacture of spirit varnishes, although a small quantity is also used in medicine Specimens of gommier resin were submitted to manufacturers of printing inks and to varnish makers, who both reported that the soft gommier resin would answer their purposes as well as elemi. Other samples were then submitted to brokers for valuation. They stated that the material was somewhat dirty, and would only be worth from 17*s.* to 18*s.* per cwt., as compared with 50*s.* to 55*s.* per cwt. obtainable for true elemi. This difference in price is probably to be accounted for by the fact that elemi is usually sold in this country in a comparatively fresh and soft condition, and that it is generally fairly free from dirt.

It is probable that gommier resin, if exported in a fresh and clean condition, would realise prices more nearly equal to those obtained for true elemi.

SALT FROM NORTHERN NIGERIA.

Two samples of salt were forwarded to the Imperial Institute by H.M. Acting Commissioner for Northern Nigeria, with the request that full information as to their commercial value might be obtained.

It was stated in the accompanying letter that the samples were obtained from the Muri Province of the Protectorate, but no information was given either regarding the deposits furnishing these products, or as to whether the samples consisted merely of the crude material as collected or of salt prepared from this by native methods.

The samples were analysed in the laboratories of the Scientific and Technical Department of the Imperial Institute, with the following results:—

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SALT FROM Northern Nigeria.

Specimen "No. 1, labelled 'Native salt from the Awe Province of Muri.'

This consisted of coarse crystals, which were moist and slightly greyish-brown in colour. The material had a purely saline taste, and was not bitter.

Specimen No. 2, labelled "Native salt from Azara Province of Muri."

This closely resembled No. 1 in appearance and properties.

Composition of samples.

	Number 1.		Number 2.	
	As Received.	Dried at 100° C.	As Received.	Dried at 100° C.
	Per cent.	Per cent.	Per cent.	Per cent.
Sodium chloride, NaCl	85·37	96·16	85·49	95·76
Potassium chloride, KCl	—	—	0·61	0·69
Calcium chloride, $CaCl_2$	2·39	2·69	2·35	2·63
Magnesium chloride, $MgCl_2$ ..	0·65	0·78	0·69	0·78
Sulphates soluble in water	trace	trace	nil	nil
Matter insoluble in water	0·38	0·43	0·15	0·17
Moisture by difference	11·21	nil	10·71	nil

These results show that the samples contained an unusually high proportion of calcium chloride, and as a consequence of the presence of this impurity they were abnormally moist, since calcium chloride has the property of absorbing moisture from the atmosphere and retaining it. The other impurities contained in the samples were present only in small quantities, and were such as are frequently found in commercial salt.

Since calcium chloride is very soluble in water it was obvious that these samples of salt could be greatly improved by solution in and re-crystallisation from water, and it was found that by a single treatment of this kind perfectly white crystals of salt could be obtained from both samples. The purified product so made from No. 1 contained only 0·36 per cent. of calcium chloride, and that from No. 2, 0·47 per cent. of this impurity, the rest being practically pure salt. These quantities of impurity are not in excess of those found in many of the purified salts of commerce.

Crude, impure salt of the quality represented by these samples would be of very little value in commerce, but the refined products, which could be obtained by dissolving these salts in hot water, allowing the solutions to deposit suspended insoluble matter, and then crystallising out the salt, would be similar in composition to the white salt of European trade.

Salt from Northern Nigeria.

which at present has the average value of 16s. to 17s. per ton f.o.b. at an English port.

In 1901 salt to the value of 4,102*l.* was imported into Northern Nigeria, and in 1902 the value of the imports of this commodity into the Protectorate rose to 7,965*l.*; it is, therefore, a matter of great importance to the country that an investigation of the extent of the salt deposits in the Province of Muri should be carried out, and the possibility, or otherwise, of establishing a salt industry in that district ascertained.

STARCH PREPARED FROM THE BREAD-FRUIT TREE IN THE SEYCHELLES.

Two small samples of powder prepared from the bread-fruit tree were forwarded to the Imperial Institute by the Governor of Seychelles, with a request that a report upon their composition and commercial value should be furnished. It was stated that the samples were prepared in the island of Praslin, near Mahe, and a copy of a report by Dr. Denman, the chief medical officer, upon a previous sample of the powder was enclosed. From the latter it appeared that the powder was practically pure starch.

The two specimens were labelled as follows:—

(I.) "*État naturel de la poudre,*" and (II.) "*La même poudre tamisée.*"

(I.) "*État naturel de la poudre.*"

This specimen consisted of about 200 grams of a whitish powder, which exhibited a faint yellow tinge; it contained numerous small hard lumps, but these could be readily reduced to a fine powder. The sample possessed a slight odour, resembling that of arrowroot, and had a starchy taste.

(II.) "*La même poudre tamisée.*"

This was a very fine whitish powder, which also exhibited a faint yellow tinge. It was perfectly free from lumps, possessed the same odour and taste as the preceding specimen, and closely resembled fine wheat flour in appearance. The sample weighed about 150 grams.

Starch Prepared from the Bread-fruit Tree in the Seychelles.

The results of the chemical examination of the two specimens, conducted in the Scientific and Technical Department of the Imperial Institute, were as follows:—

—	*État naturel de la poudre.*		*La même poudre tamisée.*	
—	Sample as Received.	Calculated for Dry Material.	Sample as Received.	Calculated for Dry Material.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	17·09	—	17·18	—
Fibre	0·12	0·15	Trace	Trace
Fat	0·19	0·21	0·21	0·25
Proteid	0·48	0·58	Nil	Nil
Sugar	Trace	Trace	Trace	Trace
Starch	81·64	98·72	82·39	99·43
Ash	0·28	0·34	0·27	0·32
Phosphoric acid (P_2O_5), in ash	0·08	0·10	0·09	0·11

These analyses, confirmed by microscopical examination, show that the powders consist of practically pure starch, the percentages in the dry material being 98·7 and 99·4 respectively. Small amounts of ash and fat were present in both samples, the percentages being almost the same in each case, and in the unsifted sample there was 0·58 per cent. of proteid.

The specimen of the sifted powder was submitted for valuation to brokers who were informed of the results of the chemical examination. So far as can be judged from the small sample available, they think that there would be a good demand for the material at about £7 per ton, c.i.f. London, but point out that a definite opinion cannot be expressed until a larger sample of about 10 lb. is submitted for practical trials. They state that it would not be advisable to forward consignments without an order, and that the material would have to be available in large quantities, say from 100 to 200 tons at a time, before buyers would be disposed to take it up.

The present price of American powdered starch is about 8*l.* 10*s.* per ton in London, so that the value of the Seychelles product might improve as it became known on the market.

II.—GENERAL NOTICES RESPECTING ECONOMIC PRODUCTS AND THEIR DEVELOPMENT.

(Prepared by the Staff of the Scientific and Technical Department.)

ARTIFICIAL VANILLIN AND ITS EMPLOYMENT AS A SUBSTITUTE FOR VANILLA.

Vanillin is the constituent to which vanilla owes its aroma and flavour. It was discovered in 1858 by Gobley, and was subsequently investigated by a number of chemists, notably by Tiemann, who first prepared it artificially from coniferin, a glucoside found in certain coniferous plants. Since that time a number of processes for the artificial preparation of vanillin on a commercial scale have been devised. The first of these to meet with commercial success was that of De Laire (English Patents, 1890, No. 17,547 ; 1891, No. 17,137), who used as a starting point *eugenol*, the substance to which oil of cloves owes its characteristic odour. De Laire's process, either in its original form or slightly modified, was worked commercially in France and in Germany during the period 1891-1896, without producing any material change in the price of vanillin. About 1897, however, a period of competition set in between the various makers, which was further accentuated by additions, in France, Germany and Switzerland, to the number of firms manufacturing vanillin. The result has been that the price of this product, which was 9*l*. per lb. in 1890, has steadily fallen until in November last it was quoted at 1*l*. 1*s*. 4*d*. per lb.

It is probable that all the vanillin so far placed on the market has been made from eugenol, and its price has therefore been governed by that of oil of cloves as the raw product. In 1901, however, a patent (No. 310,983) was taken out in France by Vigne, in which an electrolytic method for the preparation of vanillin from sugar was described. If the claims of the inventor are borne out by practical trials on an industrial scale, it is probable that a further reduction in price may be expected, owing to the great difference in cost of the two raw products, eugenol and sugar.

There is no trustworthy information as to the extent to which artificial vanillin is manufactured and used at the present time, but to judge from the number of firms engaged in its production the amount must be considerable.

As regards the effect of the manufacture and sale of "artificial vanillin" upon the demand for vanilla, it is remarkable that this has up to the present been comparatively slight. When it is considered that vanilla is employed principally as a flavouring agent, and that its value in this respect depends upon

Artificial Vanillin and its Employment as a Substitute for Vanilla

the amount of vanillin it contains, it is curious that so recently as November last good qualities of vanilla should be saleable at 17s. to 19s. 6d. per lb., whilst the equivalent amount of artificial vanillin for flavouring purposes could be obtained for about one-thirtieth of this cost. It is probable that this preference for vanilla over artificial vanillin is due partly to conservatism on the part of the consumers, and partly also to a somewhat widespread belief that vanillin does not wholly represent the flavour of vanilla, which, it is alleged, is partly due to minute quantities of other aromatic substances present in the pods. Some evidence in favour of this view is furnished by the statements made at various times by chemists who have examined particular varieties of vanilla, and have isolated, in addition to vanillin, small quantities of heliotropin, benzoic acid, &c. These substances are, however, both cheap and readily obtainable, and if necessity arose it would be a very easy matter to mix them in a proper proportion with vanillin in order to modify the flavour of the latter in the required direction.

The foregoing statement of the present condition of vanillin manufacture indicates clearly the possibility in the near future of the replacement of vanilla as a flavouring agent by vanillin.

It is difficult to obtain reliable statistics of the production of vanilla since the cultivation of this product is so widely distributed in tropical countries, and the imports of it into the principal consuming countries are comparatively of so little value that they are rarely separately given. The United States Trade Returns for 1902, however, give a table of the imports of vanilla into that country for the decennial period ending in 1902, of which an abstract is given below:—

Imports of Vanilla into the United States of America.

Year	Weight.	Value.	Average Value per lb.
	Lbs	Dollars.	Dollars.
1894	171,556	727,853	4·2
1896	335,768	1,018,608	4·2
1899	272,174	1,285,412	4·5
1900	255,986	1,209,384	4·7
1901	248,988	875,229	3·5
1902	361,789	859,399	2·3

These figures show that, although there is at present no falling off in the demand for vanilla in the United States, there has been a great decline in value.

The same state of things is shown by the results of the two auctions held in London in February and November of last year. At the former 2,800 tins were sold, and at the

Artificial Vanillin, and its Employment as a Substitute for Vanilla.

latter 1,410 tins. These quantities are in excess of those of former years. The prices obtained in February ranged from 22*s*. 6*d*. per lb. for best qualities, to 14*s*. 6*d*. for somewhat short, chocolate-coloured beans, and 7*s*. 6*d*. to 11*s*. 6*d*. for "foxy brown" beans. In November the best qualities realised only 17*s*. to 19*s*. 6*d*. per lb., short beans from 8*s*. 6*d*. to 11*s*., and poor qualities 4*s*. to 7*s*. per lb.

It is almost impossible to give accurately the total annual production of vanilla at the present time, but it may be estimated at about 350 tons, of which about 150 tons are produced in the British Colonies and Bourbon, and the remainder in Mexico. Such statistics as are available indicate that the total production has remained almost stationary during the last few years, the increased output from Seychelles and Mexico being compensated by smaller exports from Mauritius and Bourbon. This being the case it is evident that the depreciation in value of vanilla must be ascribed almost entirely to the competition of vanillin as a flavouring agent. In this connection it is desirable that it should be known that the so-called "artificial vanillin" is identical in every respect with the vanillin contained in vanilla, and to which the flavour of the plant is chiefly if not entirely due.

THE CULTIVATION OF THE CENTRAL AMERICAN RUBBER TREE, (*CASTILLOA ELASTICA*.)

The United States Department of Agriculture has recently issued a pamphlet—Bulletin No. 49, Bureau of Plant Industry—upon this subject, written by Mr. O. F. Cook, who gives the results of a preliminary study upon the cultivation of Castilloas in Guatemala and Southern Mexico. The work was chiefly undertaken with the object of ascertaining whether the trees could be successfully introduced into Porto Rico and the Philippines, and the information already obtained is considered to be distinctly promising from this point of view. The investigation is being continued by Mr. Cook, so that a further bulletin upon the subject may be anticipated, but it was thought desirable to publish a preliminary account of the experiments and observations, together with references to work upon other rubber-yielding plants which may have a bearing upon the cultivation of the Central American rubber tree. The bulletin forms a convenient summary of the information at present available upon the subject, and the following account will indicate the scope and character of the work.

The Cultivation of the Central American Rubber Tree.

The cultivation of rubber trees is only in an experimental stage at the present time, but during recent years considerable progress has been made, and the conditions of success are now much more clearly understood than formerly. The cultivation of Castilloas has been chiefly taken up in Central America and Southern Mexico, and a short time ago it was ascertained that 26 companies in Mexico possessed plantations covering 11,117 acres, and containing 5,443,105 trees. The total area devoted to the cutivation of Castilloa in Mexico alone is estimated at about 20,000 acres, whilst numerous plantations have been established in the other Central American countries and also in Columbia and Venezuela.

Botanical characters—The first description of *Castilloa elastica* was given by Cervantes in a paper read in the City of Mexico on 2nd July, 1794, in which the generic name of the plant was written *Castilla*. Subsequently this name became changed to *Castilloa*, by which the plant is now universally known, but Mr. Cook proposes to go back to the original form, Castilla, according to the recognised rule of botanical nomenclature. In this abstract, however, the current form of the name will be retained.

In 1885 Sir Joseph Hooker described four species or varieties of Castilloa depending principally upon the characters of the fruits, but he did not assign new botanical names to these. Later, Koschny has asserted that there are four distinct species of Castilloa existing in the forests of Costa Rica, and has described them as *C. alba*, *C. nigra*, *C. rubra* and *C. Tunu*. The first three of these yield rubber, whereas the fourth furnishes a brittle resinous product called "gutta-percha" by the collectors. The seeds of the different species are stated to be quite indistinguishable, but the trees themselves can be recognised by the characters of the bark, the colour of which is indicated by the specific names of the rubber-yielding forms. Koschny considers that *C. alba* is the only species suitable for cultivation, and thinks that the poor results which have been obtained in certain districts from cultivated Castilloas were probably due to the fact that the wrong species had been employed for the experiments.

Mr. Cook found that the most conspicuous difference which could be detected between the Castilloa of Alta Vera Paz, in Eastern Guatemala, and that of the Soconusco district of Southern Mexico, was in the scales of the male flower clusters, which in the former case were larger and more closely adpressed than in the latter. It is stated in a footnote, however, that further investigation has shown that more than one species of Castilloa is being cultivated in Central America and Mexico, but detailed information upon the point

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is not yet available. It would be a considerable advantage to planters if the alleged differences in the rubber-yielding qualities of the several species of Castilloa could be fully investigated and finally settled, and it is to be hoped that the work now in progress will accomplish this. There is no doubt that the species of Castilloa known by the natives as "ule macho," furnishes little or no rubber, but the published statements regarding the rubber-yielding species require further elucidation.

The bulletin contains a complete botanical description of Castilloa, in the course of which its curious habit of producing temporary deciduous branches in the early stages of its growth is noticed. As a rule the true or permanent branches do not appear before the third or fourth year.

Distribution.—It seems probable that wild Castilloa trees occur in all the forests of Guatemala, with the exception of those which are too wet, and they are found there at considerable altitudes, though the yield of rubber diminishes as the altitude increases. In some districts the trees yield a thick latex which does not flow readily and coagulates in the incisions to form shreds of rubber which when aggregated constitute the scrap rubber of commerce. In this feature the trees differ from those of Southern Mexico, as well as in the character of the scales of the male flower clusters. The most productive rubber districts of Guatemala are situated in the neighbourhood of La Gomera, near the Pacific coast, where the establishment of plantations of the trees has just been commenced.

In Southern Mexico wild Castilloas are more common, being very numerous in the neighbourhood of Tapachula and La Zacualpa. They are occasionally found in the rather open forests near the coast about San Benito, but do not occur on the Isthmus of Tehuantepec between Juile and San Juan Evangelista. They are met with in the region about Petes, both north and south, but only sparingly, and there is no indication that the trees were ever abundant in this district.

All the wild Castilloa trees seen in Guatemala and Southern Mexico are described as of medium rather than of large size, and of slender habit. The largest was found near Tapachula, and had an estimated height of 80 ft. and a circumference of 7 ft. at 5 ft. from the ground.

From his observations, Mr. Cook concludes that the districts which are well adapted for the cultivation of Castilloa in Southern Mexico and Central America, are much more limited than is generally supposed, as the presence of wild trees is insufficient evidence that a locality is suitable for the establishment of plantations.

The Cultivation of the Central American Rubber Tree.

Cultivation and Propagation.—A question which has aroused considerable discussion in connection with the cultivation of Castilloa trees is whether they require to be shaded by larger trees or whether they can be grown successfully in situations where they will be exposed to full sunlight. Opinions upon this point are exceedingly varied, some authorities advocating that the trees should be grown under forest conditions, others that they thrive best in perfectly open situations, whilst others again prefer conditions intermediate between these two extremes. It is quite possible that the question does not admit of any general solution owing to the fact that the most suitable conditions may be determined by the local peculiarities of climate and soil, but it seems probable that the two latter methods are much preferable to the first.

The author claims that Castilloa is not a genuine forest tree, and that in the wild state it thrives better in open situations than in the denser forests. This view was also adopted by Koschny, who states that *C. alba*, the only species which he considers suitable for cultivation, is never found in the deep forest, but in more open places, where the foliage can receive the sunlight. It has been clearly demonstrated that in certain districts the cultivated trees thrive best in fairly open situations, and that even young seedlings do not suffer from full exposure to the sun provided the soil does not become too dry. In less humid situations, however, it may be desirable to plant Castilloa under shade or in partially cleared forest.

In the cultivation of rubber trees a point of considerable importance is the production of a large straight trunk, as this greatly facilitates the tapping operations. It has been found that Castilloa trees growing in the open often send out permanent branches 8 or 10 ft. from the ground, whereas those in the forest may have from 20 to 40 ft. of smooth trunk before the permanent branches are reached. This disadvantage attaching to open cultivation can be easily remedied, however, by planting the trees sufficiently closely, but without overcrowding, in which circumstances they will produce tall, straight trunks suitable for tapping, and at the same time the additional foliage has a beneficial effect by increasing the shading of the soil. To attain this object the trees are usually planted in rows from 12 to 20 ft. apart, with a distance of 8 to 12 ft. between the individuals; planting closer than 10 ft. is, however, of doubtful expediency.

Castilloa trees can be propagated from seeds or by cuttings. The seeds have thin coats and quickly perish when kept in even a moderately dry atmosphere. They require to be specially packed for transport, the most favourable conditions being that they should be kept sufficiently moist to prevent loss of

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vitality without inducing actual germination. The seeds are usually sown in nurseries, though some planters prefer to place them at once in the situations which the trees are to occupy. When raised in nurseries the seedlings are transplanted either when very young or at the end of a year. At La Zacualpa transplanting is commenced when the seedlings are six weeks old, or when they are from 10 to 12 in. high, and it is claimed that at this stage they suffer much less from the operation than do the older plants, and that the subsequent rate of growth is greater.

Castilloas can be propagated very readily from cuttings, but care must be taken in the selection of the latter, as the temporary branches of the trees will not serve for the purpose. It also appears probable that cuttings containing mature wood root much better than succulent shoots. In connection with this method of propagation it is suggested that experiments might be made on the possibility of improving Castilloa as a rubber producer by taking cuttings from the most productive trees and determining whether the plants thus obtained will give a similar high yield of rubber. Such experiments would be of considerable interest and, if successful, would have an important bearing upon the future of the industry by increasing the average yield of rubber from the trees. It is to be hoped, therefore, that planters may be induced to carry out the experiments necessary to determine the point.

Latex.—Considerable attention is devoted to a discussion of the various problems presented by the latex or "milk" of rubber trees, in the course of which the different views current among botanists regarding the functions of the latex in plant metabolism are reviewed. The yield of rubber from a particular tree depends upon the amount of latex which can be obtained from it and the percentage of rubber which this contains, and will therefore be affected by any circumstances which exert an influence upon either of these factors. The flow of latex will occur most readily when the internal pressure in the trunk is highest, and the period at which this condition is realised will vary according to climate and conditions of growth. Consequently, the best time for tapping the trees will vary in different districts; in those having a humid climate the collection usually takes place during the dry season, whereas in drier regions the commencement of the rainy season is the recognised time. It is also possible that even in the same district it might be found advantageous to tap trees, growing under varying conditions, at different times in order to obtain the best results. It has been asserted that less rubber can be obtained from trees in open situations than from those growing in the forest or under shade, but this statement appears to rest upon tapping experiments made during the dry season only, which cannot therefore be accepted as conclusive.

The Cultivation of the Central American Rubber Tree.

There is considerable evidence to show that a continuously humid climate is neither necessary nor desirable for the successful cultivation of Castilloa, the indications being that the quantity of latex and percentage of rubber are both increased by an alternation of wet and dry seasons. Trees in dry situations yield little latex whenever the supply of water is inadequate, but at the commencement of the rainy season they furnish a much larger quantity than is obtained from trees growing in continuously humid districts. As would be anticipated, the percentage of rubber in the latex is greatest during the dry season, but diminishes during the rainy period, when the latex becomes more fluid.

Tapping.—The determination of the best methods of tapping the trees is of vital importance to rubber cultivators, as the success of the plantations will largely depend upon the way in which the operation is conducted. The object in view is to obtain the maximum yield of latex from the trees without impairing their future productiveness, and many practical questions arise in connection therewith, such as, for example, the age at which the young trees may first be tapped, the best manner of making the incisions, how often the tapping may be repeated, and at what seasons, and many others. Several of the most important of these points are considered in the bulletin.

The age at which Castilloa trees can be safely and advantageously tapped for the first time has been very variously stated, but the general plan is to leave them for eight or ten years. There is very little inducement to tap the very young trees on account of the inferior quality of the rubber obtained, and from Weber's experiments it appears that eight years is about the minimum age at which the trees will yield marketable rubber.

A large amount of work has been done on several of the principal rubber trees in order to determine the kind of incision which will furnish the greatest yield of latex, and the different methods of tapping which have been introduced as the result of these experiments are briefly described. In the case of Castilloa it is concluded that when the latex flows freely the maximum yield can be obtained with least injury to the tree by means of separate oblique incisions, but when the latex is thicker, and coagulates in the cuts, as in eastern Guatemala, horizontal incisions appear to give the best results. Attention is drawn to the fact that experiments in the Straits Settlements have shown that the largest yield of rubber can be obtained from *Hevea brasiliensis*, the Para rubber tree, by what may be termed "multiple tapping," in which the edges

The Cultivation of the Central American Rubber Tree.

of the wound are cut repeatedly in order to permit a fresh flow of latex. It has been found that when this method is employed the flow of latex may be continued for several days, in some cases actually increasing in amount from day to day, and a *much greater yield of rubber is obtained than by any other process. Mr. Cook suggests that similar experiments might* be tried with Castilloa to see whether it will respond in the same way to this treatment.

Coagulation.—The methods employed for the coagulation of the latex, in order to obtain the rubber, vary considerably in different countries, and for the different trees, most of the native processes being extremely crude and unsatisfactory. The various methods in actual use for Castilloa latex are noted, and prominence is given to the process suggested by Weber, in which the albuminoids are eliminated from the rubber by the use of formaldehyde. No new work has been done upon this portion of the subject, however, so that no detailed notice is necessary.

The experiment of smoking Castilloa latex, in the same way that Para rubber is prepared in Brazil, has been tried at La Zacualpa, but the result was a hopelessly sticky mass. This difference in behaviour is probably due to differences in the composition of the latex of the two trees rather than to any variation in the character of the actual rubber.

Mr. Cook describes a method of coagulation, which he saw in use at La Zacualpa, in which the latex is spread in a thin layer upon the large banana-like leaves of a species of Calathæa laid out on the hot bare ground and fully exposed to the sun. The latex darkens with great rapidity, and in a few minutes it has become sufficiently firm to permit a second layer to be spread on. Subsequently, two of the leaves have their rubber-covered faces pressed together by being trodden upon, when the rubber adheres, to form a single leaf-like sheet, from which the leaves themselves are easily stripped away.

With reference to the amount of rubber which can be obtained from a Castilloa tree at a single tapping, the most trustworthy evidence available tends to show that 2 lb. per tree may be regarded as the reasonable maximum yield from trees of 12 years and upwards growing under favourable natural conditions.

The bulletin concludes with a statement of the profits and prospects of Castilloa culture, which has been drawn up for the information of the American public in view of the attempts now being made to exploit the rubber industry commercially. Since it has been found that a continuously humid climate is neither essential nor desirable for the cultivation of Castilloa it is thought that there is a reasonable prospect of establishing the industry in Porto Rico and the Philippines, and it is suggested that small experimental plantations should be established in both places.

The Cultivation of the Central American Rubber Tree

The bulletin contains a number of excellent plates illustrating *the general appearance of Castilloa trees, their botanical characters, the methods of tapping, and the preparation of the rubber.*

FODDER AND LAWN GRASSES SUITABLE FOR CULTIVATION IN WEST AFRICA.

Considerable attention is at present being given in the various British Colonies and Protectorates of West Africa to the selection of fodder and lawn grasses for cultivation. It has been considered desirable, therefore, in consultation with Kew, to collect and publish in the Bulletin such information as is available regarding grasses suitable for cultivation in tropical countries, particular attention being devoted to their nutritive values as fodders.

In all agricultural countries a regular and adequate supply of fodder for horses and cattle is a matter of great importance, and in many temperate climates a definite portion of the farm or estate is almost invariably devoted to raising grasses or other fodder, in part to supply the wants of the summer, and in part to be preserved for use during the winter. In the tropics the extent to which this practice should be adopted depends largely on climatic conditions and the character and quantity available of the wild grasses. In places where there is no long continued dry season, fresh fodder may be obtainable all the year through, and the provision of a store of food is, in ordinary seasons, unnecessary. Where, however, there are well marked wet and dry seasons, it is often as requisite to make provision for the latter as for a winter.

This is commonly effected by the preservation—as hay or ensilage—of fodder grown during the wet season, or by the cultivation of grasses which yield crops during the dry season.

The question whether hay or ensilage is the more advantageous for tropical countries is one on which opinion differs. Where the grasses to be preserved attain their most nutritious

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stage at the onset of the dry season, haymaking, which is simple and inexpensive, may be recommended. On the other hand, where the grasses ripen during the wet season, haymaking is practically impossible, and ensilage should be resorted to. No general rule of universal application can be laid down, the question is one to be solved experimentally for each locality with due regard to climatic seasons, the ripening periods of the grasses, and the relative expense of production, keeping power and nutritive value of the products. The second method suggested of securing fodder during the dry season, namely, by the cultivation of grasses which yield crops at that time, is one of great practical importance. On the sugar estates in Barbados, to take an actual example, a definite area is commonly maintained in a grass known locally as "sour grass" (*Andropogon pertusus*), which thrives and furnishes excellent crops during the dry season when all other fodder is scarce. This grass, which is described below, has already been recorded from West Africa, and is well worthy of careful attention.

To turn now to the particular case of West Africa, the problems to be solved are: The provision of a supply of fodder during (1) the wet season; and (2) the dry season, the latter being either ensilage, hay, or grasses which yield crops during this time. The plants to be employed must perforce be either native or introduced, but in the first instance attention should be directed to the former, as their presence is proof of their suitability to the local conditions of soil and climate. West Africa is fortunately already well supplied with grasses of known value, and some, for example "Guinea grass," have been distributed thence throughout almost all the tropics, and are universally held in high esteem. The fact of the country possessing many wild grasses of known feeding value should not be regarded as rendering it unnecessary to take further steps to secure a supply of fodder. Adverse seasons or other abnormal conditions may render the supply inadequate, or costly, and the experience of other parts of the world has shown that it is often more economical to cultivate the best grasses rather than to rely on indigenous sources of supply.

Wherever possible experiments should be made to determine the feeding value of the grasses. The composition of a particular grass varies sometimes very considerably in different districts of the same country, and in collecting specimens the locality should be carefully noted with each, in the hope of ascertaining the conditions necessary to producing grass of the greatest nutritive value. When it is necessary to attempt to introduce other grasses, small plots of each only should at first be grown, at experiment or botanic stations, or in other places where they will be well looked after, and preferably in as many

Fodder and Lawn Grasses suitable for Cultivation in West Africa.

parts of the country as possible to test their suitability to various conditions.

Having obtained—by the selection of the native grasses, or by the experimental cultivation of introduced grasses, a number well adapted to local conditions, of high, nutritive value, palatable, and capable of affording fodder at all seasons of the year, it remains to cultivate them to the greatest advantage. When it is intended to allow cattle to graze on the grasses, hedges of some kind are usually desirable, so that the animals may be excluded at times when by too close grazing they would do harm. Trees should also be planted over the land to afford shade to the cattle during the heat of the day; one of the best trees for this purpose is the well-known "Saman," "Guango," or "Raintree" (*Pithecolobium saman*), which affords a grateful shade, and in addition bears large quantities of fleshy pods much appreciated by cattle for food.

Grasses, like other crops, cannot be reaped and removed continually without impoverishing the soil, and from time to time, especially on poor soils, applications of manure will be required.

Periodical tillage and weeding will also be required to keep the land in good order and to prevent the growth of the woody weeds or "bush" which spring up so rapidly in tropical countries. Beyond these general precautions grass cultivation in the tropics requires no greater care than in temperate countries, but it is very important, especially in starting new cultivations, to give the preference to a grass which is hardy, and covers the ground well to the exclusion of other species, rather than to one of, perhaps, a slightly higher nutritive value, but requiring great care and attention to enable it to hold its own.

Notes are given below on the more important fodder grasses recorded from West Africa. This list contains so many of what are regarded in other parts of the tropics as the most generally useful fodder plants that it would not appear necessary at present to seek elsewhere for other species until these have been thoroughly tested. Many of them are already held in high esteem in West Africa.

Amongst the perennial grasses mentioned, Guinea grass (*Panicum maxicum*) is undoubtedly the most important for general purposes. It is of high nutritive value, responds readily to cultivation, hardy, and thrives from the sea level to elevations of 4,000 or 5,000 feet.

Para grass (*Panicum muticum*) is especially to be recommended as a permanent grass for swampy localities.

In dry regions, and on poor soils, *Andropogon pertusus*, and *Stenotaphrum americanum* will thrive and yield good crops, and the former will be found of great value in dry seasons, dder and awn rasses itable r Culti- ation in Vest frica.

whilst *Cynodon Dactylon* will grow in such extreme situations as sand just above high water mark, or rubbish heaps, and withstand most severe droughts.

For lawns *Cynodon Dactylon* is the most generally useful.

Andropogon pertusus.—Wild. "Palwa" (India). "Sour grass" (Barbados).

A perennial grass, 1 to 4 ft. high, with narrow leaves and a slight underground creeping rootstock. The value of this grass as a fodder plant is recognised in many parts of the world. It is "met with all over the plains of Northern India, and is universally esteemed as a good fodder grass both for grazing and stacking" (Duthie). In parts of Australia it is regarded as one of the best grasses to withstand long droughts, while it will bear any amount of feeding (Mueller).

In Barbados it is the principal fodder grass and is cultivated almost to the exclusion of all others. In the driest districts and on the most exposed places this hardy and excellent fodder plant thrives and furnishes, at the time of the year when other fodder is scarce, food for the animals employed on the sugar estates. Cut shortly after flowering it forms valuable fodder for horses, cattle and mules, who eat it with relish, but if left to get over ripe, the stems become hard and unpalatable. "Sour grass" is easily propagated by root cuttings planted about one foot apart; it quickly spreads, covering all the ground, and goes on growing for many years giving two or three crops annually. (Bovell, "West Indian Bulletin," II., p. 238.)

Beyond its value as a green fodder it is a good grass for making hay.

The following analysis of "sour grass" hay grown in Antigua is given by Watts:—

	Per cent.
Water	10·9
Ash	5·5
Crude protein	5·0
Fibre	29·7
Carbohydrate, &c.	37·7
Fat	2·0

Andropogon pertusus is recorded from Accra, and if it is not already grown for fodder, steps might well be taken to encourage the cultivation of this important fodder grass.

Anthistiria australis (Themeda Forskalii *Hack*).—"Kangaroo grass" (Australia).

This important grass is widely distributed and is found in many parts of South Africa and Australia, where it "often almost exclusively covers wide extending plains and mountain slopes." It has strong roots which, penetrating deeply into the ground, enable the plant to remain green even in very

Fodder and Lawn Grasses suitable for Cultivation in West Africa.

dry weather. The usual manner of propagation is by root division.

Cynodon Dactylon (Pers.).—This grass has a very wide distribution, occurring in many tropical, sub-tropical and even temperate regions. It is known in various localities by a large number of names, amongst those most generally in use being Bermuda grass (U.S.A.), Bahama grass, Devil grass (West Indies), Durba (Bengal), Dub or Doub (N. India). Without doubt it is a useful and valuable grass, growing freely on poor soils and waste places where other grasses will not thrive, and having a remarkable power of withstanding protracted droughts.

"In the Southern States it is the most important grass for pasturage, and, as in Hindustan, it is prized for fodder both for horses and cows."

Bermuda grass is a creeping, perennial grass, rooting at every node, and forms long, wiry, underground stems. It varies in height from about two inches on poor ground to about two feet on good soil.

The underground stems render it very resistant to drought, but at the same time make it very difficult to eradicate in places where it has become established. For this reason it should only be grown where it is to remain permanently.

In Hooker's "Niger Flora" (184) there is no mention of the grass as occurring on the West Coast of the African mainland, although it is recorded from the Cape de Verd Islands. It can easily be propagated by either seeds or rootstocks, the latter being the means usually adopted in countries where a stock of the grass is available. If seeds are employed they should be sown broadcast like other grass seeds. If roots are available, nothing more is necessary than to place small pieces at intervals of, say, nine inches in the cleared ground, where they will readily grow, and soon cover the surface. Planting should be done at a time of the year when rain is expected.

The following analyses of this grass are recorded by the U.S.A. Department of Agriculture:—

	Fresh. Per cent.
Water	14·3
Ash	7·8
Fat	1·3
Nitrogen free extract (starch, sugar, &c.)	45·0
Crude Fibre	19·9
Albuminoids	11·5

Euchlæna luxurians **("Teosinte"). An annual grass allied to the maize, and indigenous to Guatemala, whence it has been in-**

Fodder and Lawn Grasses suitable for Cultivation in West Africa.

troduced into the West Indies, the United States, India, Lagos and South Australia.

It grows well and produces large crops of green fodder on good soil and when thoroughly irrigated, but it cannot withstand drought.

Panicum maximum (Jacq.).—" Guinea grass."

This grass, as its name suggests, is a native of western Africa. According to the usually accepted story, it was introduced accidentally to Jamaica in 1774, in the form of seed, as bird food. The birds are stated to have died, and the seed, being thrown away, produced a crop of fine grass which was greedily eaten by horses and cattle. For many years Guinea grass has been the principal fodder grass of Jamaica, where it is thoroughly acclimatised, and ranges from sea level to between 4,000 and 5,000 feet. The grass is also known and highly appreciated in other of the West Indian islands.

It has also been introduced to Ceylon, where it thrives in almost all soils and situations, and at elevations up to 4,000 feet. Guinea grass and Para grass are regarded as the two most valuable fodder plants of Ceylon.

In parts of Australia and the United States also the grass has a high reputation.

These notes will serve to indicate that in the native Guinea grass agriculturists in West Africa possess ready to hand a stock of one of the best of tropical fodders, and one which is sought after in many other parts of the world. Every care should be taken to improve the character and yield of this crop, by adopting some of the general means of improvement of grass land suggested.

Chemical analysis of Guinea grass hay. From Watts, " West Indian Bulletin, III.," p. 353.

	Per cent.
Water	13·4
Fat	0·7
Protein (crude)	4·1
Carbohydrates	38·0
Fibre	34·0
Ash	9·5
True protein	2·6

An interesting series of analyses of Guinea grass grain in various districts in Jamaica is given by Cousins, in the " Bulletin of the Department of Agriculture, Jamaica," vol. i., p. 243. It is pointed out that whilst Guinea grass " is without question the most valuable general-purpose fodder-grain in Jamaica," it shows great variation in chemical composition according to the soil and district upon which it is grown. The grass from one district, for instance, was found to be of little

Fodder and Lawn Grasses suitable for Cultivation in West Africa.

higher feeding value than good oat hay, whilst that from another locality was equal to good Timothy grass in general feeding value.

Panicum muticum (Forsk).—"Para grass," "Mauritius grass," "Scotch grass," "Water grass," "Buffalo grass."

A native of South America, whence it has been distributed, in great measure through the activity of the Royal Gardens, Kew, to many parts of the world.

It is a rather coarse, perennial grass, spreading rapidly by means of long trailing shoots which root freely at every node.

On low swampy ground or on irrigated land it thrives and well repays cultivation, yielding heavy crops of excellent fodder. In Ceylon, the West Indies, and other countries it is regarded as one of the most valuable pasture grasses.

In Jamaica, Para grass is highly thought of. "For growing stock and milk production the Para grass shows a decided superiority to "Guinea grass" under the same conditions. The nitrogenous constituents are in a most favourable proportion. The grass is undoubtedly of high value in those districts to which it is well suited. (Cousins, "Jamaica Bulletin," I., p. 244.)

The following analysis of the fresh grass is recorded by Watts ("West Indian Bulletin," vol. iii., p. 354).

Water	72·9	per. cent.
Fat	0·2	„
Crude protein	1·3	„
Carbohydrates...	13·8	„
Fibre	9·6	„

The grass is easily propagated by spreading small pieces of the rather succulent stems broadcast over the ground and covering with a little soil.

Para grass is incapable of withstanding drought and should only be planted in places where it can obtain a plentiful supply of water. On account of its power of rapidly spreading it should not be planted amongst cultivated crops.

In Hooker's *Niger Flora*, a single specimen of this or of a closely allied species was recorded by Vogel from Aboh.

Panicum spectabile (Nees).—On the Niger this has been reported as "an aquatic grass, six feet high." In East Africa it is noted "as supplying the richest fodder for cattle." In other parts of the world it is also held in high esteem, and Hackel states that it is "an extremely productive fodder grass for tropical countries, and is largely cultivated in Brazil."

Paspalum conjugatum (Berg.).—"Sour grass". (Jamaica). "Green grass" (Singapore).

A low perennial grass, rooting freely at the nodes and rapidly covering the ground to the exclusion of other plants. It is known in the West Indies, Ceylon and the Straits Settlements, and appreciated for its rapid growth, power of withstanding drought, and the quality of the fodder it affords to horses and cattle.

Vogel records it as occurring from Sierra Leone to the Quorra and Fernando Po.

Paspalum distichum (Burm.).—"Silt grass." "Water couch."

A prostrate perennial grass, with running stems, thriving on banks of streams, the edges of ponds, &c. Mueller states (*Select Extra Tropical Plants*): It keeps beautifully green throughout the year, affords a sufficiently tender blade for feed, and is exquisitely adapted to cover silt or bare slopes on banks of ponds or rivers, where it grows grandly; moderate submersion does not destroy it, but frost injures it; it thrives well on salt marshes. A chemical analysis gave the following results:—

Albumen	2·2	per cent.
Gluten	7·7	„
Starch	1·5	„
Gum	1·6	„
Sugar	5·0	„

In California a suggestion has been made to grow it in ponds which dry up, or nearly so, during part of the year. Vogel reports it from the "sandy shores of the Nun."

Paspalum scrobiculatum (Linn.).—Fundi, or Fundungi (Sierra Leone), Kodo, or Koda millet (India), ditch millet (New South Wales), *Herbe à épée* (Mauritius).

A grass about 2 or 3 ft. high, described from some countries as an annual, from others as a perennial. It is esteemed a valuable pasture grass, and is stated to grow on poor land and also on swampy ground.

Investigation would have to be made as to the properties of this grass, and although cattle may eat it readily when young, it is stated to cause narcotic poisoning when the grain is ripening, and that during this time cattle should be carefully excluded from the fields.

Pennisetum typhoideum (Rich.).—"Kous." "Gero." "African millet." "Gussub." "Bajra" (India). "Pearl millet."

"An annual grass of luxuriant growth, frequently reaching

6 or 8 ft. in height with long, broad leaves. The stalks are freely productive of suckers which furnish a large amount of sweet, succulent leaves. It is supposed to be a native of Africa, but has been known from time immemorial in cultivation in India, Arabia, and Egypt" (Vasey).

Fodder and Lawn Grasses suitable for Cultivation in West Africa.

This grass is of recognised value as a fodder in the Southern United States, Ceylon, &c., in addition to its importance as a source of grain.

Being already well known in Western Africa it is unnecessary to add more concerning its uses. Its cultivation for fodder might be extended in suitable localities.

Saccharum officinarum (L.).—Sugar-cane.

In sugar producing countries, when the canes are reaped, the "tops" or leafy portions are cut off and form a valuable fodder. During the crop season they are given to the estate animals in the fresh state, and they may also be preserved for use during the remainder of the year by simply heaping them in stacks; the best method being to dry them until they form a kind of rough hay, and then tie in bundles and closely pack them in the stacks.

Recent investigations by Watts ("West Indian Bulletin," vol. iii., pp. 359-361) proves that by this method their nutritive qualities are satisfactorily retained.

The following analysis from the paper quoted gives the composition of the "tops":—

	Per cent.
Water	68·41
Fat	·26
Crude protein	1·35
Carbohydrates	16·62
Fibre	11·12
Ash	2·23

Stenotaphrum americanum (Kunth.).—Pimento grass (Jamaica). Buffalo grass (Australia).

A perennial creeping grass, admirably adapted, according to Mueller, for binding sea sand and river banks, for forming garden edges, and for establishing a grass sward on lawns. In Central Australia it has proved capable of keeping alive in the hottest and driest regions, withstanding severe frost, and also showing itself adapted to recently reclaimed swamp land. Mueller adds: "It consolidates rolling sands into a firm pasture-turf." On the thin soils of the island of Ascension this grass proved of great value for fodder.

"It flourishes on dry limestone soils in Jamaica, and affords nourishing food for animals pastured under the pimento trees" ("Kew Bulletin").

The following analysis is recorded in the "Bulletin of the Department of Agriculture, Jamaica," vol. i., p. 244, by H. H. Cousins.

	Green Grass. Per cent.
Moisture	80·7
Fat, wax, &c.	0·3
Nitrogenous matter	1·6
Carbohydrates	9·3
Fibre	6·3
Ash	1·5

MANILA HEMP AND THE FIBRE INDUSTRY OF THE PHILIPPINES.

Manila hemp, or Abaca fibre, is derived from the sheath of the leaf-stalk of *Musa textilis*, the wild plantain. Although various species of the genus *Musa* flourish in nearly all parts of the tropical and sub-tropical zones of both hemispheres, yet *Musa textilis* apparently thrives best in the Philippines. Attempts have been made to introduce it into other countries where allied species thrive, but these experiments have usually proved unsuccessful. In the year 1822 an attempt was made to grow the plant in Calcutta, and in 1859 it was introduced into Madras, but in neither case was a satisfactory result obtained.

In 1873, the plant was introduced into the Andaman Islands, and three years later 48 young plants existed, all of which had come from one original shoot. In 1879 some of the largest plants were cut down, and 43 lb. of fibre extracted from them were submitted to the Agri-Horticultural Society of India. A favourable report was received, and the opinion was expressed that if the fibre could be produced at a reasonable rate it would soon become an article of commerce. Although the plant appears to be well adapted to the Andaman Islands, yet its cultivation and the preparation of its fibre have never become an important industry, and but little attention is paid to it. The amount of fibre manufactured there during the years 1898-1902 was as follows:—1898-99, 1,032 lb.; 1899-1900, 1,240 lb.; 1900-01, 1,102 lb.; 1901-2, 1,446 lb.

Manila Hemp and the Fibre Industry of the Philippines.

In the Philippines, the cultivation and extraction of Manila hemp is the most important industry, and an account of it has been given in a recent Bulletin by Mr. John W. Gilmore, of the Philippine Bureau of Agriculture. The fibre first came into notice in the early part of the last century, but was not recognised as a product of importance until about 1850. The steady increase which has since taken place in the annual production is shown by the following figures:—

	Tons.		Tons.
1850	8,561	1900	89,438
1860	30,388	1901	109,231
1870	31,426	1902	108,265
1880	50,482	1903	130,159
1890	67,864		

In order that *Musa textilis* may develop to the best advantage, a uniformly moist and warm climate is necessary. The plant occurs almost throughout the entire Philippine Archipelago, but yields the best results in the Provinces of Albay, Camarines Norte and Sur, Sorsogon, and the islands of Masbate, Mindoro, Marinduque, Samar, Leyte, Cebu, Southern Negros, and parts of Mindanao. The plant is best adapted to a soil rich in humus and naturally well drained; it will not thrive in marshy land. It is easy to cultivate, but in order to obtain good crops a situation should be selected in which the plant is sheltered from excessive rain and wind. The plants are arranged at a distance of from 5 to 8 ft. from one another, and during their period of growth require little or no attention; it is necessary, however, that the fields should be weeded occasionally. Most plantations are provided with trees for the purpose of shading the young plants and protecting them from the violence of the wind.

The plant may be propagated by means of seed, but it is usually grown from suckers which arise from the root of the parent plant. The fibre has attained its highest tensile strength at the period when the flower-bud has just reached the summit of the plant. Harvesting is effected by cutting the stalk near the root and afterwards stripping off the leaf-sheaths. The suckers are left attached to the stump, and by this means the crop is constantly renewed. The leaf-sheaths are cut into strips of from 2 to 3 in. in width, and the fibre is

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generally extracted by drawing these strips between the edge of a blunt knife or "bolo" and a hard, smooth, wooden block attached to a light frame constructed of rattan canes.

The yield of fibre varies according to the locality in which the plant is grown. In districts which have a heavy rainfall the yield amounts to 687 to 967 lbs. per acre, but in provinces in which the climate is less humid it may not exceed half this quantity.

A number of machines have been introduced for the purpose of extracting the fibre economically, but none has come into general use; this has been due either to inefficiency of the machines or to prejudice of the native workers. The greater part of the Manila hemp is prepared on the hillsides or very rough ground where it has been cultivated, for it has been found most profitable to extract the fibre in the plantations, and thus avoid the cost of carriage of the heavy stalks. One of the principal requirements of a decorticating machine, therefore, is lightness and portability. It is also important that the machine should be capable of avoiding the waste created by the present crude method in which it is estimated that from 20 to 30 per cent. of the fibre is lost.

Manila hemp is characterised by great tensile strength combined with lightness, and for this reason is particularly well adapted for the manufacture of ships' ropes and cables. In the Philippines, some of the finer qualities of the fibre are woven into textile fabrics, and a small quantity of the fibre is employed in upholstery, packing, and brush-making.

The economic resources of the Philippines include a large number of other fibrous plants, but only one of these, Maguey fibre, is an article of export at the present time. Cotton, ramie, and pineapple fibre are produced in these islands to a small extent, and are employed by the natives for local manufactures. Pangdan, burri, nipa, and rattan are also grown, and are extensively used for various purposes.

Maguey Fibre.

Maguey is a term which has been used by Spanish-speaking people to designate various species of *Agave*. In 1891 specimens of the leaves of the plant which furnishes the Maguey fibre of the Philippines were forwarded to Kew by H.M. Consul at Manila, and were identified as those of *Agave vivipara.*

The plant usually occurs on stony or sandy soil, but is capable of growth on soils which differ widely in physical structure and capacity of retaining moisture. It bears a rosette of 20 to 40 thick, fleshy leaves of from 3 to 7 ft. in length, which rise directly from the ground. These leaves have spines along their margins, and terminate in a hard, horny point. The plant is capable of withstanding protracted drought, but in a humid atmosphere it produces fibre of greater length and elasticity.

The cultivation of Maguey is carried on in the islands of Panay, Cebu and Mactan, and in the northern provinces of Luzon. The plants are arranged at a distance of 6 ft. from one another in rows which are 8 ft. apart. The life of the plant varies from 12 to 30 years. The leaves are mature in three years from their first appearance and are then gathered. Each plant produces about 25 leaves annually yielding approximately 1½ lb. of fibre. When the plant has reached maturity the flower-stalk undergoes rapid elongation, rising sometimes to the height of 15 feet. The plant only flowers once and then dies. The flower spikelets bear numerous small slips or suckers which fall to the ground and are collected and planted out in rows. Propagation is effected either by means of these slips or by means of the suckers which arise in the axils of the lower leaves.

The fibre is extracted by macerating the leaves in water and afterwards scraping away the pulp. In some localities this treatment is preceded by crushing the leaves and leaving them in heaps to ferment. Machinery is not used at present in the Philippines for the preparation of this fibre, but there is no doubt that some of the machines used so largely in Mexico and the Bahamas for extracting Sisal hemp could be adapted to this purpose.

Maguey fibre is soft, elastic, of a wavy appearance, and, if carefully prepared, is white and lustrous. It is employed in the manufacture of ropes and cables, and also of lines, nets and hammocks. This fibre is not exported from the Philippines in large quantities; during the year 1901, 875 tons were exported of the value of about 20*l.* per ton.

Pineapple Fibre.

The pineapple is widely distributed throughout the Philippines. In some localities it is cultivated for the sake of its fruit, whilst in certain provinces of Luzon, and in the islands of Panay and Cebu, it is grown for the production of fibre. It has been claimed by Mr. Perouttel that the pineapple of the Philippines is not botanically identical with *Ananas sativus* (the true pineapple), but is a species of *Bromelia*; this, however, is at present unconfirmed.

The pineapple plant does not thrive in wet soils, but is best adapted to a porous, well-drained soil, and is capable of withstanding protracted drought. It is generally propagated by means of the suckers which arise from the parent plant near the ground, but can also be reproduced by means of slips. When the plant is being grown for its fibre, the fruit is removed soon

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after flowering has taken place in order that the leaves may develop more freely.

The fibre is extracted in the following manner:—The epidermis of the leaves is first removed by means of a blunt iron or wooden scraper. A layer of fibre is thus exposed and is lifted with the fingers or a small spatula. The scraping is then repeated and a second layer of fibre is exposed which is in turn removed. This process is continued until the whole of the fibre of the leaf has been extracted. The fibre is washed with water, and dried and bleached by exposure to the sun.

A mature plant usually bears about 40 leaves from 1½ to 3 in. broad and from 2 to 5 ft. long. A ton of these leaves, numbering about 22,000, yields from 50 to 65 lbs. of dry fibre. Attempts have been made to extract the fibre by means of machinery, but up to the present the machines tested have not proved commercially successful.

Pineapple fibre is white, very fine, and, at the present time, is worth about 30*l*. per ton on the London market. It is employed in the Philippines for the manufacture of the fabrics known as "pina" and "rengue," which are valued at from 1*s*. to 3*s*. per yard, and are meeting with a growing demand both in Europe and America. The fibre is also used for making small cordage of great strength.

In 1897 a specimen of pineapple fibre produced in India was examined in the Scientific and Technical Department of the Imperial Institute. The results showed that the sample possessed good spinning qualities and was very promising in character. The value of the fairly clean fibre in the London market was at that time about 20*l*. to 25*l*. per ton.

Cotton.

Cotton has never been an article of export from the Philippines, although it is grown throughout a considerable area. The species cultivated is *Gossypium herbaceum*, but *G. arboreum* also occurs to a smaller extent. The average production of "lint" is about 165 lb. per acre, but in 1893 a yield amounting to 315 lb. per acre was obtained in some of the northern provinces of Luzon. The total annual production, which probably has never exceeded 100 tons, is insufficient for the local manufactures, and considerable quantities are, therefore, imported.

The nature of the soil, the conditions of labour, and the local demand for the fibre render the Philippines well adapted for the cultivation of cotton.

Ramie.

A small quantity of ramie is produced in the Philippines, and is employed for mixing with Manila hemp, silk and pineapple fibre in the manufacture of a number of fabrics. The

Manila Hemp and the Fibre Industry of the Philippines.

local supply, however, is not sufficient to meet the demand, and has to be supplemented with imported fibre.

Miscellaneous Fibres.

Pangdan.—Several species of *Pandanus*, the screw pines, occur in the Philippines. They bear thin, fibrous leaves, which are from 4 to 5 ft. in length, 1½ to 3 in. wide, and are employed in considerable quantities for making bags and mats. The mature leaves are split into strips of the desired width, and are then woven into the form required.

Burri or Talipot Palm.—This palm (*Corypha umbraculifera*) grows abundantly throughout the Philippines. It produces large, fan-shaped leaves, the leaflets of which are from 3 to 4 ft. in length, and are used for the manufacture of baskets, hats, and a coarse kind of matting.

Nipa.—The leaves of the Nipa palm (*Nipa fruticans*) are of considerable economic value, and are used by the Filipinos for thatching houses and for making hats, sails, and rain coats.

Rattan.—Species of this climbing palm (*Calamus*) occur throughout the forests of the Philippines. They furnish the well-known rattan canes, which are extensively employed in the manufacture of furniture, baskets and mats.

COCOA PLANTING IN SAMOA.

The introduction of the cocoa-growing industry into Samoa dates from 1883, when 100 trees were procured from Ceylon, and were followed in 1884 by 383 trees obtained from Java. The industry has not yet attained any great magnitude, but there are great expectations of its ultimate success, and much attention is being paid to it. In 1899 the area under cocoa was estimated at 300 acres, planted by foreign residents, and an unknown area on native lands. The Apia Customs Returns show 400*l.* worth of cocoa exported in 1901 and 625*l.* worth in 1902.

In 1903 Prof. F. Wohltmann visited Samoa on behalf of the German Colonial Economic Committee and of the German Trading and Planting Company of the South Sea Islands to investigate the condition of the cocoa planting there, and of other cultivations suited to the Samoan Islands. An account of his visit and recommendations is published as a Supplement to the January number of the "Tropenpflanzer" for 1904, and from it the following points which may be of interest to planters in British Colonies are summarised.

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The Samoan Islands, of which the two largest, Upolu and Savaii, belong to Germany, lie only 14° south of the equator, and possess a tropical but very equable climate. The usual range of temperature is from 68° to 88° F., but extremes of 66° to 94° F. have been recorded. Violent winds and thunderstorms are not of frequent occurrence, but severe hurricanes sometimes sweep over the islands, though only in every seven to nine years. The dampness of the air is not so great as would be expected in tropical islands, but it is high enough to meet the requirements of all moisture-loving tropical plants. In the rainy season, which lasts from November to March, the air is usually almost saturated with water vapour. In the dry season, lasting from April to the end of October, the hygrometer shows in the morning and evening about 90 per cent. and over of complete saturation, but at 2 p.m. about 65 to 75 per cent. is observed; this circumstance is very favourable for the drying of cocoa and of copra.

As regards rainfall, the record kept at Apia extends from 1890 onwards, and as evidence of prior conditions it is noted that only once since 1857 has the food supply fallen short and occasioned a famine. The mean annual rainfall for the 13 years, 1890 to 1902, is 115 in., and the extremes in that period are a minimum of 89 in. and a maximum of 163 in. As far as quantity is concerned, this minimum fall is sufficient for cocoa and plants needing much water, but on the Samoan coast the rain is not well distributed in the course of the year, and there are years when periods of drought last too long, and are too intense to suit the needs of the cocoa plant. If for two or three months in succession the fall is only 0·8 in. per month, the yield is very seriously threatened; for this reason suitable localities at higher altitudes should be sought when selecting land for cocoa planting, as the rainfall is heavier in such situations. It must be remembered, however, that at higher altitudes the coast variety of cocoa may not grow so well, and that above 1,600 ft. the plant is likely to fall a victim to parasitic growths and other vegetable enemies.

As the land in Samoa is very variable in its nature, before purchasing a plot, it should be thoroughly tested by digging numerous holes to examine the soil and subsoil. The cocoa tree is deep-rooted, and the most important point consequently is the existence of a considerable depth of suitable soil. The tap root usually penetrates to a depth of 4½ to 6 ft., and its course must be unimpeded if the tree is to grow to a height and maintain a thriving condition, and in times of drought a deep tap root enables the tree to draw on the stores of underground moisture. Failure has been observed to happen when the root, after traversing a layer of loam, reached a sandy layer affording only a poor supply of moisture; the disease-resisting power

Cocoa Planting in Samoa.

of the tree was diminished, and it fell a victim to a fungus which attacked its bark. The existence of standing water at a depth of 2 ft. has also caused the death of the tree. Soil extending to a depth of 4½ to 6 ft. is the best; the presence of stones is immaterial provided that they do not exceed 50 per cent. of the whole soil, and provided that the tap root does not strike against one of them in its descent; the obstruction caused by a large stone would be fatal. On this account the spot where a tree is to be planted should first be examined with the aid of an iron bar, and any stones likely to interfere with the root should be removed. Healthy trees will live for 35 years and more, and if properly treated will be serviceable for 20 years. If this preliminary testing is omitted the tree may grow luxuriously for four or five years, and then fail owing to the root reaching a sandy layer or striking on a stone. Thus for a safe system of cultivation the preparation of holes for the plants is absolutely necessary.

Owing to the looseness of the Samoan soil, when planting cocoa, either as seed or as young plants, it must be well compressed by treading to prevent any subsequent sinking in of the soil, which would be injurious to the young plant. Holes should be dug about 2 ft. deep, and the subsoil should then be further explored with an iron rod of 1½ in. to 2 in. thickness. In planting out the young trees from the nursery, care must be taken that the tap root is not bent or cracked. But little care has been bestowed on this in Samoa, and thousands of trees can be seen which have suffered in consequence, the roots having been pressed into the planting hole, and the tap root, instead of going straight down, has been bent into a curling shape or at right angles. This has happened when the planting has been left to unskilled natives with inadequate supervision. Plants thus crippled grow well at first, but never make healthy trees or reach full age, and they only yield 40 or 50 per cent. of a full crop.

The choice of seed for planting is of the greatest importance; the pods selected should not be over-ripe, and should not come from too young trees nor from diseased ones. Only seed of the best class and free from every fault should be sown. The best variety of cocoa bean to plant is one descended from the trees imported by the German Trading and Planting Company in 1883 and 1884; it is always known in Samoa as "Criollo," but is quite unlike the "Criollo" of Trinidad, surpassing it in quality; it is also unlike the "Forastero" cocoa. In fruit, nibs and form of tree it most nearly resembles the cocoa of Guatemala and Colombia; the beans are said to be as good as the best South American, and to fetch at Hamburg 50 per cent. more than the best cocoa from the Cameroons. The pod is of a dark red colour and about 6¾ in. long and 3¼ in. thick; a

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smaller form of pod is of a bright red colour, with orange furrows, and is 6 in. long and 2¾ in. thick.

As the tree increases in growth pruning is very necessary, and suckers should be removed as soon as possible. When branching has developed and it is possible to see how the young *tree is inclined to grow, it should be pruned into a proper shape, and only three or four main branches should be allowed to develop. The best shape for the tree is still a matter of opinion, but in any case it should be prevented from growing too thickly* or too high.

Wherever the cocoa is grown in an exposed position, trees to keep off the wind are necessary. For this purpose a strip of the original forest may be left, and is one of the best protections; it must be fairly wide, or it will not last; a width of 45 yards should generally be sufficient, but if the land is available 110 yards may be kept and rubber trees can be planted in this strip. In the Samoan coast lands shade trees are necessary as the dry season often lasts for six months, and is very intense; they are probably advisable, too, at the higher altitudes. Forest trees should never be left standing to act as shade trees, but for this purpose *Albizzia stipulata* may be planted; *A. moluccana* grows more quickly, it is true, but it is too easily broken by the wind, and is apt to grow excessively, requiring a liberal removal of its branches. There should be from 10 to 20 shade trees per acre, but on this point observation should be made in each locality, as no fixed rule can be made to meet the varying conditions of soil and climate. In Trinidad in many places it is the custom to have as many shade trees as cocoa trees, the trees being planted alternately. Quite recently indiarubber trees, especially *Hevea brasiliensis*, have been recommended for affording shade.

The soil of the cocoa fields must always be kept clean, that is, round about the cocoa tree; in Samoa the long, dry season is very opportune for this work, and the expense involved is scarcely a third of that in the Cameroons. Cleaning the land must be seen to from the very first, and it is most important that the jungle should be completely and properly cut down and burnt at the right time, avoiding large and deeply-burnt patches. The stems of large trees can be left to moulder away.

When the ground is cleared the planting can begin, and papaya trees, which will grow nearly everywhere, can be used as the first shade trees. As in the cultivation of fruit trees in Germany, the provision of well-cleaned land and of shade must be seen to for each individual, newly-planted tree. The planter must be on the look out for the attacks both of animals and of disease, and their causes must be discovered; they are often due to excessive shading, deficiency of light or air, or excessive moisture in the soil, and frequently can be easily remedied.

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The best methods of fermenting and drying the cocoa, and also the length of time to be allowed for the fermentation process are still undecided questions. The produce of small plantations is most conveniently treated *along with that of other planters, and this makes it advisable to have the same variety of cocoa grown by all, as different varieties require different* treatment in the final preparation.

The question of manuring is a most important one; it is true that in the higher lands where the burning of the jungle has afforded a rich supply of ashes to the soil, manuring may not be needed at first; but in the lower localities, and especially on those fields which have been used recently by the natives or reclaimed from jungle of no great age, the need for manure requires to be considered. The soils of Samoa are remarkably rich in nitrogen and phosphorus, and the addition of these elements may be set aside as not requiring much attention, but the question of supplying lime and potash to the soil and crop has to be carefully inquired into. Whether their application is necessary or profitable in a given place can only be determined by experiments; the results of soil analyses can only furnish hints as to the manure to be applied. Experiments have already been made by the German Trading and Planting Company, and are again to be undertaken.

The coral sand of the islands, which is abundant and cheap, can be used to supply lime; the wood ashes, too, which can sometimes be obtained, contain about 30 per cent. of lime, in addition to the more valuable potash. When the cocoa is harvested and prepared, the husks and pulp can be returned to the soil, but the beans are completely removed, so that the potash they contain is lost to the land.

Cocoa beans, like all fruits rich in carbohydrates, are rich also in potash. 100 Samoan cocoa beans were found to weigh 66·4 grams, of which 7·2 grams (10·8 per cent.) were shells and the remaining 59·2 grams (89·2 per cent.) were kernels. The shells contained 5·8 per cent. of ash, in 100 parts of which there were 41·6 parts of potash (K_2O), 8·0 parts of lime ($Ca\,O$), and 19·8 parts of phosphorus pentoxide (P_2O_5). The kernels contained 2·8 per cent. of ash, in 100 parts of which there were 34·8 parts of potash, 5·2 parts of lime, and 37·5 parts of phosphorus pentoxide. From this it follows that 100 lbs. of cocoa beans contain 0·88 lbs. of potash in the kernels and 0·26 lbs. of potash in the shells, making a total of 1·14 lbs. of potash. Allowing 200 cocoa trees per acre, and assuming that they yielded the exceptionally good harvest of 4½ lbs. per tree, there would be 900 lbs. of beans removed per acre, taking with them 10¼ lbs. of potash. This would be the loss if all the husks and refuse were returned to the soil, which, however, does not always

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happen, and besides this a certain amount of potash is used in producing the annual increase in size of the tree, and is consequently stored away in the wood. This estimate points to about 20 lbs. of potash as the amount that should be supplied per acre in the manure. It could be given by applying about 40 lbs. per acre of commercial potassium chloride manure, costing about 7*l*. 10*s*. at Stassfurt, in Germany, the place of manufacture; in addition to this, the cost of freight would have to be allowed for. If good wood ashes were procurable about 200 lbs. of them would give the requisite 20 lbs. of potash; but if they had been exposed to rain or wet, the valuable potash in them would have been washed out, as it is present in a soluble state.

This manuring may be expected not only to supply food to the tree, but also to improve the physical condition of the soil and increase its power of retaining moisture in dry weather. It should be applied in the dry weather when the weeding of the plantation is undertaken, and should be hoed into the surface of the soil extending to a distance of about 3 ft. from the stem all round, and this area should be covered with a layer of dead weeds to protect the soil from drying. As the upper portion of the tap root is surroundered by a thick web of crown roots, which lie close under the surface, any hoeing must always be done very superficially and with great care to avoid injuring the roots.

It is hoped that the experiments which are now being carried on in Samoa according to Prof. Wohltmann's directions will yield results of great value for the guidance of cocoa planters.

UTILISATION OF INDIAN COTTON SEED.

A considerable amount of attention is now being directed in India to the problem of improving the cotton industry in that country. In connection with this subject an interesting report has recently been issued by the Director of the Agricultural Department of India dealing with the possibility of utilising to better advantage the cotton seed now produced there. ("Agricultural Ledger," 1903. No. 9). This report contains much information which will be important to other countries in which cotton cultivation is being prosecuted.

It is pointed out in that article that the export of cotton seed from India increased from 43,485 cwts. in 1899-1900 to 3,974,000 cwts. in 1902-1903, this rise being attributed to the remunerative price which cotton-seed oil now commands in the European

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markets. It is understood that the seed at average Indian *prices can be profitably exported when the price of cotton-seed oil in England is 20l. or more per ton.*

Regarding the freight and other charges for export of cotton seed, the following estimate of expenses per ton is given:—

	Per ton. £	s.	d.
Initial cost in Bombay	3	0	0
Freight charges, Bombay to Hull ..	1	3	0
Bags, commission, insurance, &c. ...	0	12	0
	4	15	0

Egyptian cotton seed is the chief competitor with Indian seed in European markets. The former commands a higher price, as it contains a larger percentage of oil, and has no adherent "fuzz" or "velvet"; further, the cake obtained from it is considered a safer cattle food as it is more easily digested.

From a report by Professor Gilchrist of the Durham College of Agriculture, on the comparative feeding value of undecorticated cakes made from Egyptian and Indian Cotton seed; it appears that the latter is less palatable and contains more woolly fibre, but in view of the fact that the Indian cake is about 10s. per ton cheaper at Hull (according to recent quotations), it is considered that the results as a whole are in favour of the Bombay cake.

With reference to the above, it is remarked that Indian cattle do not appear to object to the woolly character of the seed, and that the hard, woolly cake made from undecorticated Indian cotton seed may possibly be more safely given to English farm stock whilst grazing on succulent grass in the summer season than when fed with dry food in winter.

From comparative analyses it is shown that undecorticated cotton-seed cake made in India contains less moisture but more oil than English-made samples.

Cotton seed has always been a valuable agricultural product in Egypt and India. In the latter country it has long been regarded as a specially good food for milch and work cattle. The percentage of oil which it contains makes it a safe food, notwithstanding the high percentages of husk and woolly fibre. The cattle of cotton districts in the Central Provinces and the Deccan are finer than those of other districts largely owing to their being fed with cotton-seed cake.

In America, oil mills equipped with the newest machinery for delinting, hulling and pressing the seed are now extensively established. The refined oil is largely used there in the preparation of butter and lard substitutes. It is also utilised

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for the manufacture of soap and salad oil, which are chiefly employed locally. The cake is exported to some extent, but is also used in the country as cattle food and as a manure.

The introduction of American methods into India would from *an agricultural point of view be preferable to a large export of cotton seed, if the by-product cake is entirely kept in the* country. The export of oil removes nothing which would add to the fertility of the land, whereas the use of the oil-cake as cattle food or directly as manure would be beneficial. Extensive exports of cotton seed not only remove a valuable cattle food, but cause a direct loss to the average cultivator in districts where ginning factories are established.

The quantities of oil seeds exported from India during 1901-1902 and 1902-1903 were as follows:—

Kind of Oil Seeds.	1901-2.	1902-3.
	Cwts.	Cwts.
Linseed	7,328,000	6,328,000
Rape seed	6,925,000	3,927,000
Sesamum	2,447,000	3,733,000
Cotton seed	2,036,000	3,974,000
Poppy seed	934,000	966,000
Earth nuts	1,085,000	1,036,000

Commenting on these figures, the author says that it is possible that these exports are more profitable to those concerned than if oil industries were fully established in India, because the cakes obtained are worth much less in India than in Europe.

In the larger villages of India excellent feeding cakes are prepared by pressing oil seeds such as sesamum, ground-nut, niger-seed, safflower and rape-seed, but cotton-seed cake is practically unknown, as this cannot be profitably prepared by native methods.

At Lahore and Akola (Berars) hydraulic press mills capable of treating cotton seed have, however, now been established.

In connection with experiments for the improvement of Indian cotton, the Director of Agriculture has investigated over one hundred indigenous and a large number of exotic varieties. The comparative values of the different varieties are shown by tabulated results for the number of seeds per tola, and the percentage quantities of oil and crude fibre contained in the seeds. By a comparison of these figures it is noticeable that the cotton races grown in the Central Provinces and the United Provinces are, taken as a whole, superior, so far as seed is concerned, to those of Madras and Bombay. It is impossible to compare in a reliable way these figures with average analyses

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of American or Egyptian seed, as the percentage of oil varies considerably in different varieties and under different conditions; but it is stated that some samples of American and Egyptian cotton seed contain as much as 10 per cent. more oil than the seed of any Indian variety, and average samples at least 5 per cent. more.

The effect of acclimatisation on exotic varieties of cotton seed was shown to be deleterious as regards seed production: the seed gradually becomes smaller, and that of acclimatised plants was found on analysis to contain less oil and more crude fibre than the indigenous varieties.

Regarding yield of oil, it is stated that Indian cotton seed would give a yield of 13 per cent. of oil if treated by proper machinery, and to test this conclusion samples of Indian seed have been sent to America for trial in the mills established there. Shipments of the seed have also been sent to Hull to test the suitability of English machinery for the treatment of Indian cotton seed.

NOTICES OF SOME RECENT UNOFFICIAL PUBLICATIONS.

THE NEW SOUTH AFRICA: ITS VALUE AND DEVELOPMENT. By W. Bleloch. Pp. xvi. + 435. (London: William Heinemann, 1901.)

This work gives an account of the economic resources of the Transvaal and Orange River Colony and the possibilities of their development under British rule. The various goldfields are described together with the rate of production of the gold and the processes employed for its extraction. The gold laws of the late South African Republic are examined. An account is given of the coalfields and of the prospects of the coal industry of the Transvaal.

The other mineral resources of the country, including diamonds, iron, silver, lead, copper, zinc, tin, cobalt, platinum, mercury, antimony, mica, building stones, &c., are also dealt with.

Attention is also given to the agricultural resources of the Colonies, the immigration question, the dynamite monopoly, the past and present administrations, and the characteristics of the Uitlander, Boer, and native populations.

The book contains numerous illustrations and maps.

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Notices of some recent Unofficial Publications.

GOLD COAST NATIVE INSTITUTIONS. By Casely Harford. Pp. xvi. + 418. (London: Sweet and Maxwell, 1903.)

The author, who has practised for some years at the Gold Coast Bar, gives an account in this book of the constitution of the native races inhabiting the Gold Coast territory. The general co-ordination of the native communities is simple: these consist of villages, provinces and states. Each village has its head man, each province its chief, and each state its king. Over the combined group of states which form a Federal Union is one of these kings; such, for instance, is the constitution of the Fanto Union. The office of King is not hereditary, but elective, and in his person the king combines the chief executive officer, the head military leader, the first magistrate, and the president of the legislative board. A special office in connection with the king's court, or even attached to the suite of a head chief, is that of "linguist," or spokesman. He is a general court functionary, uniting the offices of herald and gold cane, and is, in fact, the confidential adviser, or acts as the representative of his chief. This office, rather by nature than by ordinance, is generally hereditary. The writer has a very high opinion of the intelligence of the natives and the satisfactory working of their institutions, and upon this bases his criticisms—favourable and adverse—of the attitude displayed by different governors in their dealings with the native rulers.

COMMERCIAL GEOGRAPHY OF THE WORLD, OUTSIDE THE BRITISH ISLES. By A. J. Herbertson, M.A., Ph.D., F.R.S.E. (Chambers' Commercial Handbooks). Pp. 268. (London and Edinburgh: W. & R. Chambers, Ltd., 1903.)

This books forms the continuation of the same author's "Commercial Geography of the British Isles," published in 1899. Its object is, so far as possible, to interpret, as well as to record, the most important geographical phenomena of economic significance. The book is divided into two parts: the first dealing in outline with the economic conditions of the world in general, the second in fuller detail with those of selected typical regions. In Part I. the author treats of the influence of physical features—the distribution of land and water, and variations of climate, showing their bearing on the distribution of plant and animal life; and he deals with the relative values, sources of supply, and uses of the various minerals. Having thus discussed the fundamental distributions which largely determine the conditions of human life and commerce, he proceeds to indicate the chief manufacturing areas of the world, and to review the means of communication and transport in different parts of the globe. The first part concludes with a chapter on man as a producer of wealth, and examines the effect

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of material surroundings on the intensity of man's work, the influence of thought and ingenuity in increasing his productive powers, and the effect of human associations in promoting and hindering economic and especially commercial development. The earlier chapters of Part II. are devoted to regions producing on the whole mainly raw materials, and discuss the physical conditions, economic products, means of communication, and internal and external trade of British North America, Australasia, India and Ceylon, Central Africa, and Inter-tropical South America, and the insular and peninsular lands between the Tropics. The later chapters treat of countries with moderate or extensive industrial development, beginning with the simpler, such as the Chinese, Japanese, and Russian Empires, and progressing through the lands bordering on the Mediterranean to countries of more and more complex, economic development, including France, the Alpine and Danubian lands, the German Empire, the Low countries, the Scandinavian countries, and the United States of America. The appendix contains statistical tables derived from "The Statesman's Year Book" for 1901, 1902, and 1903, or compiled directly from official returns.

ST. HELENA: THE HISTORIC ISLAND, FROM ITS DISCOVERY TO THE PRESENT DATE. By E. L. Jackson. Pp. 343, with photographic illustrations. (London, New York and Melbourne: Ward, Lock & Co., Ltd., 1903)

The first part of this book, which is devoted to the history and geography of the island of St. Helena, records its discovery in 1502 by Juan de Nova Castilla, the Commodore of a Portuguese fleet, and gives details of its successive utilisation by Portuguese, Dutch, and British as a store island for ships from India, China, and the East up to the time of the opening of the Suez Canal. The topography of the island is minutely described, and full particulars are given of its natural features, of its unique vegetation, and of its native and acclimatised animals. Extracts from the records and from letters which passed between successive governors of the island and the home authorities afford an insight into the early laws relating to the tenure of land, and into the social and economic condition of the people throughout their history.

AUSTRALIND: WANDERINGS IN WESTERN AUSTRALIA AND THE MALAY EAST. By Henry Taunton. Pp. xi. + 247. (London: Edwin Arnold, 1903.)

The author describes his experiences of travel and life on up-country sheep and cattle stations, first in the Nibi-nibi country, which lies some 30 miles inland from Champion Bay, and subsequently in the Murchison River, Sharks Bay, Roebourne, King's Sound, and Kimberley districts, where he spent nearly seven years in fishing for mother-of-pearl shells and for true pearls among the islands off the north-west coast of Western Australia.

NYASALAND UNDER THE FOREIGN OFFICE. By H. L. Duff, of the British Central Africa Administration. Pp. xvi. + 422, with illustrations and map. (London: George Bell & Son, 1903.)

The portion of Central Africa described in this volume comprises the whole of the British Central Africa Protectorate, and is not restricted, as the title might suggest, to the territories bordering on Lake Nyasa. The author's official connection with the administration of the Protectorate dates from the beginning of 1898, and during his early residence in the country, he was stationed successively in the three districts of the Shiré Highlands—Zomba, Blantyre, and Mlanje—and then at Nkata Bay on Lake Nyasa, after which, in 1900, he was appointed to take charge of the Zomba district.

The first two chapters contain a brief review of the circumstances which resulted in the proclamation of a British Protectorate over the territory in 1891, and its subsequent history up to 1898, after which the story assumes the form of a personal narrative, in the course of which an account is given of the scenery and the conditions of life in the country. The flora and fauna are described in a separate section, special attention being given to the insects, reptiles and big game; and a chapter is devoted to an account of the organisation of a hunting expedition. The author appears to have made a particular study of the ethnology of the different native races which inhabit the country, and he gives an account of their tribal organisation, their physical, mental and moral qualities, their rites, customs, religion and superstitions and their industries. A sketch of the Government of the Protectorate is also given, with special reference to its attitude towards the natives. The volume concludes with a brief account of the religious missions in the country, and a reference to the adjoining territory of North-Eastern Rhodesia.

BASUTOLAND: ITS LEGENDS AND CUSTOMS. By M. Martin. Pp. viii. + 174. (London: Nichols & Co., 1903.)

The authoress of this book spent 1891 and the ten following years in Basutoland. She lived in various parts of the country, and having acquired the language, had opportunities of studying the inner life of the people and their habits and customs from birth to marriage and death. These observations she records together with some Basuto legends; she also gives an account of their history and of the events that led to Basutoland being placed directly under the Imperial Government.

INDIAN AND COLONIAL COLLECTIONS.

RECENT ADDITIONS.

The Indian and Colonial Collections of the Imperial Institute are devoted to the illustration of the economic products and commercial resources of India and the Colonies. These Collections are contained in the galleries situated behind and running parallel to the main building of the Institute. The arrangement is geographical, the galleries being divided into "courts" each of which is usually assigned to one particular colony.

Fairly representative exhibits of the products of many of the Colonies have been available to the public for some time, whilst others are now being arranged.

Many of the Sections are at present receiving additions and undergoing complete re-organisation and re-arrangement, in co-operation with the Colonial Governments, in accordance with a general scheme to render them of greater value for technical purposes and be a means of extending general knowledge of the Colonies and their economic resources, and to assist persons desirous of emigrating, in gaining information about the conditions and mode of life in the Colonies, as well as for illustrating the progress of applied science in the utilisation of economic products.

General information regarding each colony is being provided by means of geographical, geological and meteorological maps and special maps indicating the distribution of the principal crops, minerals, etc.; whilst specially prepared tabular statements are employed to illustrate data supplied by the Governments concerned regarding area, population, revenue and expenditure, and trade, with details relating to the relative values of the more important products. The specimens of the products are classed in the first instance as vegetable, animal or mineral, and subdivided according to their uses; vegetable products falling into such groups as food-stuffs, timbers, gums, resins, and drugs.

As far as possible samples of the finished article as produced in the Colony will be exhibited together with the raw material, and intermediate stages. Photographs are being employed to illustrate characteristic scenes in the cultivation, collection or manufacture of products and by means of specially drawn up labels, concise information is being provided as to properties, uses, and supply available.

When this work is completed it is hoped that each Court will give an accurate representation of the economic resources of a Colony, and that the Collections will prove an important factor in extending public knowledge of the Colonies, and in furthering their economic development.

RECENT Additions. Collections.

Straits Settlements and Federated Malay States.—Considerable progress has been made in the re-organisation of this Court, on a plan prepared last year by Professor Dunstan, which was approved by the Government of the Straits Settlements, by whom the work of collecting and preparing in the Colony the new exhibits required, was entrusted to Mr. H. N. Ridley, M.A., Director of Botanic Gardens and Forests at Singapore. Much assistance has kindly been given by Mr. Leonard Wray, F.Z S, Curator of the Government Museum at Perak, whilst on leave in this country.

The Straits Court is being re-modelled in accordance with the general scheme for the improvement of the Collections, the object in view being to render the exhibits of greater value to commercial men, for educational purposes, and as a means of bringing to public notice recent developments in economic research. To this end the specimens have been thoroughly overhauled and a representative series selected for exhibition. Temporary labels have been added giving information describing the collection and manufacture of important products, and the local uses of other products, many of which do not appear as exports. These temporary labels are being replaced as rapidly as possible by fuller, specially prepared, printed labels, and when this work is completed it will be possible for the visitor to learn, as completely as the specimens allow, the method of cultivation, collection and manufacture of the products, and the uses to which they are put.

The tin industry has received special treatment in view of its paramount importance, and a complete series of specimens and photographs, illustrating the modes of occurrence of the tin ores, the methods of mining and smelting, have been placed on exhibition with full descriptive labels. Specimens illustrating the application of tin to the native manufacture of articles of every-day use, such as bowls, tobacco boxes and trays, have been received recently from Singapore, and have been placed on exhibition in the Court.

The geology of the peninsula is illustrated by a set of specimens with notes on the occurrence, geological age, and economic importance of the several formations.

Rice, sago, sugar, rattan canes, gutta-percha, rubbers, dammar, resins, fibres, gambier and other tanning materials, dye stuffs, spices, &c., are similarly represented by selected specimens and descriptions of their collection, manufacture and uses.

Statistical tables showing the area, population, revenue, expenditure, trade and exports, prepared by the local Government, have been placed in the Court.

An important addition is a large map specially prepared for the Court, showing the several Settlements and States under British administration, the railways, and other features of interest.

Recent Additions to Collections.

British North Borneo.—A collection of the commercial products of British North Borneo, including timbers, coal, rice, sago, sugar, coffee, cacao, pepper, tobacco and cigars, camphor, gutta-percha, dammar, resins, cutch and gambier, is on view in the North Gallery.

British Central Africa Protectorate.—The collection illustrating the resources of British Central Africa, situated at the west end of the Central Gallery, has been re-arranged and labelled. The principal products of the Protectorate are represented; foremost amongst these being [coffee, which has recently become the chief article of export, and of which some good samples from the Shiré Highlands are shown. There are also exhibits of rubber in the form in which it is brought in by natives, and of strophanthus seeds, a characteristic product of tropical Africa, formerly used as an arrow poison but now exported in considerable quantity to European countries for use in medicine. A detailed description of these exhibits was given in the "Imperial Institute Bulletin," Vol. I., page 12

Zanzibar and Pemba.—Progress is being made with the rearrangement of the exhibits in this section. The collection, which is located at the west end of the Central Gallery, contains samples of the clothing worn by the natives, soap, washing blue, and specimens of agricultural implements · the local produce is represented by samples of cloves, chillies and copra. The remainder of the exhibit illustrates the trade which is carried on between Zanzibar and the mainland. Statistical information concerning the trade of the islands is supplied, and the new labels explain the nature of the various articles which are displayed.

LIBRARY.—RECENT ADDITIONS.

Books and Publications, exclusive of Government Publications, presented by Publishers and others to the Library of the Imperial Institute since 31*st March*, 1904.

Transactions of the Royal Historical Society. Vol. XVII., 1903 ... ... (*The Secretary*).

Trade Relations of the British Empire ... By J. W. Root. (*From the Author*).

Missions to the Punjab and Sindh .. By R. Clark. (*The Church Missionary Society*).

History of South Africa, 1828-1846 ... By G. McCall Theal. (*Messrs. Swan, Sonnenschein & Co.*).

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Recent Additions to Library.

Elements of Mining and Quarrying ...	By Sir C. le Neve Foster.
The Cyanide Process	By J. Park. (*Messrs. Chas. Griffin & Co.*).
India: Our Eastern Empire	By P. H. Gibbs.
Australasia: The Britains of the Pacific	By P. H. Gibbs. (*Messrs. Cassell & Co.*).
Growth of English Industry and Commerce	By W. Cunningham. (*Messrs. C. J. Clay & Sons*).
Disinfection and the Preservation of Food	By S. Rideal. (*Sanitary Publishing Co.*).
Oilfields of Russia...	By A. B. Thompson. (*From the Author*).
Treatise on Manures	By A. B. Griffiths. (*Messrs. Whitaker & Co.*).
Wonderful Story of Uganda	By J. D. Mullins. (*The Church Missionary Society*).
Food for the Tropics	By F. M. MacKnight. (*Messrs. Thacker & Co.*).
Nile Quest...	By Sir H. H. Johnston.
Penetration of Arabia	By D. G. Hogarth. (*Messrs. Lawrence & Bullen*).
South American Republics	By T. C. Dawson. (*Messrs. Putnams' Sons*).
Commercial Geography	By C. C. Adams. (*Messrs. Appleton & Co.*).
History of the British Nation	By G. M. Wrong. (*Messrs. Appleton & Co.*).
Anglo-Afrikander Taal Guide	By J. C. Everett. (*Messrs. Keliher & Co.*).
Journal of the Canadian Mining Institute, 1903	(*The Secretary*).
Paper-makers' Directory, 1904	(*Messrs. Marchant, Singer & Co.*).
Natal Directory, 1904	(*Messrs. P. Davis & Evans*).
Sand's Sydney Directory...	(*Messrs. Gordon & Gotch*).
Stock Exchange Official Intelligence, 1904	(*The Secretary, Stock Exchange*).
Delagoa Directory, 1904	(*Messrs. A. W. Bayly & Co.*).

SCIENTIFIC AND TECHNICAL DEPARTMENT.

I.—REPORTS ON RECENT INVESTIGATIONS.

ROCKS AND MINERALS FROM BRITISH CENTRAL AFRICA.

At the instance of H.M. High Commissioner and Consul-General for British Central Africa, a series of mineral and rock specimens was collected in various districts of British Central Africa in 1900 and forwarded to the Scientific and Technical Department of the Imperial Institute, in order that they might be identified and those of probable economic importance chemically examined, so that some knowledge might be gained of the little known geology and mineralogy of the Protectorate.

As the collection included a large number of rock specimens which, though of no immediate economic value, were of great interest in affording some information as to the geological structure of the country, they were submitted to a geologist for determination and classification.

It has long been known that as a whole the formations of the southern portion of the African continent bear considerable resemblance to those of peninsular India, and the specimens were therefore referred to Mr. T. H. Holland, Director of the Geological Survey of India, then in England, who was asked for his opinion as to their probable mode of occurrence and significance in indicating the character of the formations which are present, as well as the products of economic importance, they may be expected to contain.

They were at the same time chemically examined in the Scientific and Technical Department of the Imperial Institute, and where it seemed desirable analyses were made.

A report embodying the substance of Mr. Holland's notes and results of the chemical examination has been despatched to the Government of British Central Africa, and from this the present summary has been compiled.

The specimens may be arranged in the following groups, according to the formations from which they appear to have been derived:—

(1) *Granitoid gneiss.*
(2) *Upper group of schists and gneisses.*
(3) *Transition azoic shales and sandstones.*
(4) *Intrusive gabbro and decomposed peridotites.*
(5) *Gondwana rocks.*
(6) *Trap flows and basic dykes.*

(1) The granitoid gneiss.—This group rarely contains minerals of economic importance. It is represented in this [illegible] [illegible] [illegible] [illegible] ntral rica.

collection by a biotite granite of a common type from the Marimba District on the west coast of Lake Nyassa. Apparently this belongs to the rocks referred to by Livingstone (*Missionary Travels, London*, 1857), as forming large masses in the highlands to the west of the Batoka country.

(2) Upper group of schists and gneisses.—These rocks frequently contain valuable mineral deposits, and to them may be referred the specimens of crystalline limestones and iron ores in this collection.

The iron ores resemble those of India, and are composed of a mixture of magnetic and hæmatite. The specimens were obtained from the following localities:—(1) Western slopes of Manganic Hill, near Mlangeni; (2) the bed of the Maporā River, Lower Shire District; (3) six miles west of the Chikwana main road.

The first of these contained 69·9 per cent. of metallic iron, with 0·023 and 0·038 per cent. of phosphorus and sulphur respectively, the second 69·9 per cent of iron, with 0·010 per cent. of phosphorus and 0·008 per cent. of sulphur and small quantities of titanium and copper, and the third 70·94 per cent. of metallic iron.

These are, therefore, iron ores of the best quality, rich and pure like those of Southern India, but it remains to be seen if they occur in sufficient quantity and are situated near enough to limestone and coal to be worth working or whether it will be possible to transport them to a smelting centre.

The crystalline limestones resemble those which, in Ceylon, India and Burmah are associated with the Charnockite series, and in which many gemstones are found. Phlogopite mica also occurs near the junctions between the limestone and Charnockite rocks. The Central African specimens contain sphene, pyrites, and diopside, as is usually the case with these rocks, but show no gemstones. These limestones are never found sufficiently transparent to be useful for optical purposes. It is, however, just possible that crystalline carbonate of lime that could be so employed might be found in the amygdaloidal basalts of the trap flows. Three of the limestone specimens are from the bed of the River Makirenda in the Port Herald district; the fourth, which is much purer, is from the Lake Shirwa district.

The graphitic schists, of which three specimens are included in the collection, are too poor to be of commercial value, but the localities should be searched for veins of graphite. These specimens resemble the graphitic schists which occur in Travancore and other parts of peninsular India near the junction of the Charnockite series and the crystalline limestone. One specimen is from the bed of the River Makirenda in the Port Herald district, presumably near the crystalline limestones. A second is from the Marimba district and the third from the bed of the River Tundu in the Port Herald district.

Rocks and Minerals from British Central Africa.

To the same group may be referred the following rocks, which, however, have in themselves no economic value.

Garnetiferous biotite gneiss, from the bed of the River Tundu in the Port Herald district, leptynite (garnetiferous quartz-felspar-granulite) from the same district and from the bed of the Mapora River in the Lower Shire district. Hornblende gneiss from the same two localities and hornblende pyroxene-gneiss from the bed of the last-mentioned river; hornblende and hornblende-diopside rocks from the Anglo-Portuguese western boundary and from the beds of the rivers, Makirenda and Mapora. Granulitic felspar rock from the bed of the Mapora River and garnetiferous amphibolite and quartz epidote schist from the Marimba district.

A number of vein rocks which occur among the specimens are probably associated with the schists. They include a talcose rock with pyrites and calcite and a brecciated limestone with cavities which, from their shape, must have been formerly occupied by specular iron ore; both of these are from the neighbourhood of a sandstone ridge near the delta of the Zambesi. Specimens of vein quartz were also collected from the source of the Tanjazi River and from the beds of the River Makirenda, another river in the Port Herald district, and the Mapora. Three specimens of quartz and schorl (black tourmaline) are probably derived from the coarse granitic veins known as pegmatites, two of these are from the west slopes of Mangani Hill and one is supposed to come from the Anglo-Portuguese boundary. It is not improbably from quartz reefs in the hornblende schists and epidiorites like those of the South of India, that the gold has been washed out and concentrated in the sand of some of the other rivers. Livingstone (*op cit.* pp, 630, 637) has referred to considerable gold washings in the Mokorozi and Revubu Rivers, which have tributaries descending from the Shire country north and north-east of Tete.

No gold has been detected in the specimens from this group of rocks transmitted to the Imperial Institute, but that is no reason for discontinuing the search. For this purpose there is no better guide than washing the river sands until the source of gold is approximately located. The only specimen in the collection which contains more than a trace of gold is a decomposed basalt from a mineral vein near the red sandstone ridge already referred to. On assay this yielded 1 dwt. 16 grams of gold and 1 oz. 17 dwt. of silver per ton.

(3) Transition azoic rocks.—A few of the specimens resemble the ancient unfossiliferous rocks of Peninsular India, including the Cuddapah, Gwalior, and Vindhyan formations. A dirty jasper and a porcellanite from the neighbourhood of the sandstone ridge are common Cuddapah and Vindhyan types. A quartzite from the Port Herald district may also be placed here. Some carbonaceous shales from the beds of the Makirenda and Mapora Rivers and from the Msalambidwa Hill and the frontier near Msalamted Hill might belong either to this group or to the Gondwana rocks.

(4) **Intrusive gabbros and peridotites.**—A coarse-grained gabbro from the Tundu River may be referred here, and perhaps also the pebbles of ilmenite from the Malaka River in the Lower Shire District and the decomposed fragments of felspar with pyrrhotite from the bed of the Makirenda River. Specimens from the neighbourhood of this river and from the bed of the Mapora River resemble the products of the decomposition of peridotites in South India. There the peridotites contain valuable veins of magnetite and in one case chromite. A specimen of serpentine from near the source of the Lilonjwi is probably an altered peridotite, but it is doubtful with what rocks it was associated.

(5) **Gondwana rocks.**—The coals present the peculiar characters of the Gondwana coals of India, and although this is not in itself sufficient evidence for safe correlation, there is little doubt from what is definitely known of German and Portuguese East Africa that these really belong to the Gondwana period.

From an economic point of view these are the most important specimens in the collection, and a detailed expert examination of the coal-bearing areas ought certainly to be carried out. It may be added that analyses made at the Imperial Institute agree exactly with the composition of the coal from the Gondwana rocks of India.

Although the forests supply at present the fuel consumed in British Central Africa, coal will in future be needed both for the railways and lake steamers. The thickness and extent of the good seams should therefore be ascertained as soon as possible.

(6) **Trap flows and basic dykes.**—A large number of the specimens are igneous rocks of basaltic types; some may have come from the dykes, but most of them are evidently from trap flows, like the Deccan trap of India and the plateau basalts of British and German East Africa. It is from these traps that the rounded fragments of chalcedony have been obtained. They are worthless, but agates of ordinary types which may have some small value no doubt also occur. A mass of well crystallised scolecite a zeolite mineral is derived from the traps.

GENERAL REMARKS.

The specimens leave much to be desired, both from the scientific and economic point of view. Many of them are river

Rocks and Minerals from British Central Africa.

pebbles without known origin, and most of them are damaged by weathering. It would be of advantage if larger specimens could be obtained from below the weathered crust of the rocks.

The results of the preliminary investigation of the collection of specimens from British Central Africa indicate that that country deserves systematic exploration for valuable minerals as has already been done in German East Africa. In this connection the materials which most deserve further investigation are the pegmatites, which yield valuable muscovite mica in German East Africa, the limestones, the coal, washings for alluvial gold, graphite, and the iron ores.

MINERALS FROM NORTH-EASTERN RHODESIA AND BRITISH CENTRAL AFRICA.

A series of minerals was forwarded to the Imperial Institute by the Acting Deputy Commissioner and Consul for British Central Africa, together with a descriptive report compiled by the Head of the Scientific Department at Zomba, giving certain information regarding those specimens collected in that district.

The minerals were intended primarily for exhibition in the British Central African and Rhodesian sections of the Imperial Institute, and have been chemically examined in the Scientific and Technical Department of the Imperial Institute, in order that full information regarding their composition might be available for reference and as a basis for valuation.

The results of this examination have shown that of the four iron ores forwarded, three, viz., Nos. 13a, 13b, and 18 are of good quality and suitable for smelting. Further information should be obtained regarding the extent of the deposits from which these ores were obtained, in view of the possibility of smelting them locally or of transporting them cheaply to a centre at which they could be treated. The fourth iron ore, No. 13, is of a titaniferous character and therefore probably of little value at present. Reference may also be made to the two samples of mica, Nos. 17 and 21, which, though of little value, indicate that better mica might possibly be obtained at lower levels of the same deposits.

The specimens of limestone examined, viz., Nos. 14a and 14b, are both comparatively pure, but the former is not likely to be found in extensive deposits, and the second, owing to its pulverulent character, is of little value.

No comments need be made on the specimens of auriferous quartz examined, which, with the exception of the auriferous

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mica schist (No. 15) containing only a trace of gold, were all from well known reefs already worked.

CHEMICAL EXAMINATION OF MINERALS.

Specimen No. 13.—"Iron ore, Lusangazi District, North-Eastern Rhodesia."

Description.—Titaniferous Iron ore.

Weight.—Six ounces.

The specimen was compact, homogeneous, and slightly magnetic. It possessed a lustrous steel-grey colour, had a specific gravity 4·98, a hardness of about 6, and showed a semi-conchoidal fracture.

Analysis.

	per cent.	
Ferrous oxide (FeO) ...	10·48	Equivalent together to metallic iron, Fe 56·09 per cent.
Ferric oxide (Fe_2O_3) ...	68·42	
Alumina (Al_2O_3)	nil	
Manganous oxide (MnO)...	trace	
Cupric oxide (CuO) ...	nil	
Magnesia (MgO)... ...	trace	
Lime (CaO)	nil	
Silica (SiO_2)	nil	
Titanium dioxide (TiO_2)...	21 09	Equivalent to titanium 12·65 per cent.
Sulphur (S)	0 023	
Phosphoric oxide (P_2O_5)...	0·044	Equivalent to phosphorus 0 019 per cent.
Water	nil	
	100·05	

These results indicate that this is a fairly rich iron ore. Unfortunately, however, ores such as this cannot be smelted in blast furnaces, since the presence of titanium leads to the production of a highly infusible slag, which impedes the working of the furnace. This ore cannot, therefore, be regarded as having any commercial value at present.

Specimen No. 13*a*.—"Iron ore from North Eastern Rhodesia."

Description: Magnetite.

Weight: Three pounds.

The specimen consisted of agglomerated black crystals of magnetite, partially covered with red ochreous matter. The mineral was strongly magnetic, had a hardness of about 6, and gave an almost black streak.

Minerals from North-Eastern Rhodesia and British Central Africa.

Analysis.

	Per cent.	
Ferrous oxide (FeO) ...	10·56	Equivalent together to metallic iron, 58·27 per cent.
Ferric oxide (Fe_2O_3) ...	71·50	
Alumina (Al_2O_3)	2·03	
Manganous oxide (MnO)...	trace	
Cupric oxide (CuO) ...	nil	
Magnesia (MgO)	4·93	
Lime (CaO)	nil	
Silica (SiO_2)	9·59	
Titanium dioxide (TiO_2) ...	nil	
Sulphur (S)	0 036	
Phosphoric oxide (P_2O_5) ...	0 10	= Phosphorus, 0·042 per cent.
Arsenic „ (As_2O_3)...	nil	
Water	1·20	
	99 94	

This is a magnetite of average quality. The descriptive letter accompanying these specimens gives no information regarding the extent of the deposit from which this specimen was taken, nor as to whether the specimen was representative of the whole deposit. In the absence of these data and of any information regarding the proximity of supplies of coal and limestone to the deposit, it is impossible to say whether or not this ore could be profitably smelted locally.

Specimen No. 13*b*.—"Ironstone found on Songani Estate, British and East Africa Company, Limited, Zomba District."

Description: Magnetite.

Weight: Five pounds.

The sample consisted of several pieces, some of which were hard and compact, while others were vesicular. The mineral was black internally, but was lightly covered by red oxide of iron. It was strongly magnetic.

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Analysis.

	Per cent.	
Ferrous oxide (FeO) ...	24·84	Equivalent together to metallic iron, 66·80 per cent.
Ferric oxide (Fe_2O_3) ...	67·84	
Alumina (Al_2O_3)	2·08	
Manganous oxide (MnO) ...	0·14	
Cupric oxide (CuO) ...	nil	
Magnesia (MgO)	0·57	
Lime (CaO)	nil	
Silica (SiO_2)	2·01	
Titanic oxide (TiO_2) ...	1·83	
Sulphur (S)	0·030	
Phosphoric oxide (P_2O_5) ...	0·055	= Phosphorus, 0·024 per cent.
Arsenic (As_2O_5)	nil	
Water	1·08	
	100·47	

This is a high grade magnetite, and if the present specimen is fairly representative of the quality of the whole deposit and the latter is extensive, it should constitute a valuable source of iron. The possibility of utilising this ore locally is of course dependent upon the proximity of supplies of coal and limestone.

Specimen No. 14*a.*—"Calcium carbonate from Shirwa Island, Zomba District."

Description : Calcite.

Weight : 2½ pounds.

The specimen consisted of almost pure, crystallised calcium carbonate. It was translucent and possessed a slight yellow tint, due to the presence of a small quantity of iron. It also contained a minute quantity of phosphate. Deposits of this character are generally of limited extent, and consequently of little economic importance.

Specimen No. 14*b.*—" Limestone (top surface). Loangwa River, East Loangwa District, North-Eastern Rhodesia."

Description : Shelly limestone.

Weight : One pound.

The specimen consisted of grey, pulverulent calcium carbonate, containing fragments of small shells. It was soft and very porous.

Minerals — North-Eastern Rhodesia and British Central Africa.

Analysis.

	Per cent.
Ferric oxide (Fe_2O) Alumina (Al_2O_3)	1·52
Magnesia (MgO)	0·81
Lime (CaO)	52·58
Silica (SiO_2)	0·65
Phosphoric oxide (P_2O_5)	0·057
Loss by ignition (CO_2, H_2O, and organic matter)	44·85
	99·97

This limestone, although fairly pure, would be unsuitable for smelting operations owing to its soft and pulverulent condition. Similarly lime made from it would deteriorate rapidly, and would be of little value for building purposes.

Specimen No. 15.—"Auriferous mica schist. Lusangazi Valley East Loangwa District, North-Eastern Rhodesia."

Description: Massive quartz, containing mica.

Weight: Two pounds.

The specimen consisted of colourless, translucent quartz, containing mica irregularly distributed in segregations or thin veins. It contained a trace of gold, but no silver.

Specimen No. 16*a*.—"Quartz. Sassare Reef, North-Eastern Rhodesia."

Weight: 1½ pounds.

The specimen consisted of vesicular quartz, generally colourless and translucent, but stained in a few places with ferruginous matter. It contained 17 dwts. 15·3 grains of gold per ton, but no silver.

Specimen No. 16*b*.—"Rich Quartz, Missale Reef, North-Eastern Rhodesia. Supplied by the British South Africa Company."

Weight: 1 ounce.

The specimen was a small piece of translucent quartz, containing about seven grains of visible gold.

Specimen No. 17.—"Mica (muscovite), from Muchinga Mountains, North-Eastern Rhodesia."

This specimen of muscovite mica was an irregularly shaped plate 5½ in. by 3 in. by ¼ in. in size. It was almost colourless and transparent in thin films. It showed no continuous cleavage plane, and the surface was buckled. Such mica is of no commercial value, but better material may be obtained at greater depths.

Specimen No. 18.—"Hæmatite (oxide of Iron), from Muchinga Hills."

Description: Hæmatite.

Weight: 2 ounces.

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The specimen consisted of almost pure ferric oxide. It had a daik red colour, and gave a bright red streak.

Analysis.

	Per cent.	
Ferrous oxide (FeO) ...	0·73	Together equivalent to Metallic iron, 64·05 per cent.
Ferric oxide (Fe_2O_3) ...	90·69	
Alumina (Al_2O_3)	1·74	
Manganous oxide (MnO)...	nil	
Cupric oxide (CuO) ...	0·08	
Magnesia (MgO)	trace	
Lime (CaO)	nil	
Silica (SiO_2)	4·00	
Titanic oxide (TiO_2) ...	nil	
Sulphur (S)	trace	
Phosphoric oxide (P_2O_5) ...	0·055	Equivalent to Phosphorus 0·021 per cent.
Arsenic (As_2O_3)	nil	
Water	2·75	

This is a hæmatite of good quality, containing only small quantities of phosphorus and sulphur. If the deposit of this ore is extensive and is favourably situated with regard to supplies of coal and limestone, or if the ore can be transported cheaply to a smelting centre, it should be a valuable source of iron.

Specimen No. 19.—"Quartz—ordinary. Missale Reef, North-Eastern Rhodesia."

Weight: 4 ounces.

The specimen was a piece of translucent, massive quartz, showing specks of gold. It contained 91 ozs. 9 dwts. 8 grains of gold per ton, but no silver.

Specimen No. 20.—"Quartz. Ordinary Sassare Reef, North-Eastern Rhodesia."

Weight:—4 ounces.

The specimen consisted of translucent, massive quartz, associated with a large amount of ferruginous matter. It contained 4 ozs. 11 dwts. 11·2 grains of gold per ton, but no silver.

Specimen No. 21.—Biotite Mica from Muchinga Hills, North-Eastern Rhodesia."

The specimen consisted of black biotite mica, 3·8 in. by 1·6 in. by 1·1 in. in size. In thin films it was translucent, and was olive green in colour by transmitted light. The cleavage was fairly well developed in parallel planes, but on attempting to detach thin plates the mineral broke into small scales. Such mica is of no commercial value, but better specimens may be found in other parts of the deposit, especially at greater depths.

VEGETABLE PRODUCTS FROM BRITISH CENTRAL AFRICA.

This collection of vegetable products was forwarded to the Imperial Institute from British Central Africa by H.M. Acting Deputy Commissioner and Consul, together with a descriptive report, compiled by the Head of the Scientific Department, Zomba, giving an account of the origin and production of the several materials included in the collection. The products were primarily intended for exhibition in the British Central Africa section of the Colonial collections of the Imperial Institute, and in this connection a preliminary description of them has already been given in the Bulletin (vol. i., 1903, page 9). It was also requested in the accompanying letters that, where possible, commercial valuations of the products should be obtained and communicated to the authorities for the information of the planting and trading community of the Protectorate. Such of the products as appeared to be of special interest were therefore chemically examined in the laboratories of the Scientific and Technical Department of the Imperial Institute, and full information having thus been obtained with regard to their composition and properties, they were submitted to brokers and to technical experts for commercial valuation. The results of that work are given in detail in the succeeding sections of this report.

Particular attention may be directed to several of these products, which appear to be of special interest.

Tea.—The six samples of tea forwarded were of very good quality; they contained from 3·08 to 3·68 per cent. of caffeine, which is about equal to that contained in Indian teas. It was impossible, unfortunately, to judge of the aroma of these teas owing to their having absorbed the odour of the tobacco with which they had been packed. They were valued at from 5½d. per lb. for dust "fannings" to 7½d. per lb. for "orange pekoe." It is probable that teas grown in British Central Africa would be readily saleable, and in view of the fact that the consumption of tea is extending rapidly on the European continent, the cultivation of this product might well be extended in the Protectorate. In this connection it may be mentioned that there is a large demand for green tea in the United States, which is at present almost entirely supplied from China and Japan, although of late a fair quantity of Ceylon green tea has also been sold there. It might be worth while, therefore, for planters in British Central Africa to endeavour to produce a green tea suitable for the American market, since this would probably prove more remunerative egetable roducts om ritish entral frica.

than the manufacture of black teas to be sold in competition with the Indian and Ceylon products.

Tobacco.—The three samples of unmanufactured tobacco were found to be very similar in composition to American tobaccos. The technical experts to whom they were submitted stated, however, that their commercial value could only be determined on large trial consignments of from 25 to 50 lb. The colour and texture of the leaves were stated to be suitable, but their burning qualities appeared to be less satisfactory than those of American tobaccos. These reports indicate that with a little more care in preparation, tobacco suitable for the English market could be produced in British Central Africa.

Rubber.—British Central African rubber is already well known in Great Britain, but it was thought advisable to examine the specimens sent in order that analyses of typical samples of this rubber might be placed on record. The samples were valued at 3*s*. 2*d*. to 3*s*. 3*d*. per lb.

Fibres.—The specimen of the fibre of *Furcræa gigantea* was found to be of excellent quality, and to compare favourably with samples of this fibre procured from India, Grenada (West Indies), and Victoria (Australia). It was valued at 26*l*. to 30*l*. per ton.

The specimen of the fibre of *Sansevieria cylindrica* was less satisfactory owing to faulty preparation; if properly prepared its value would be 25*l*. per ton. A second sample of this fibre more carefully prepared should be sent to the Imperial Institute for examination.

Beeswax.—Three samples of this product were forwarded, of which only one had been clarified. This sample was submitted to brokers, who reported that it would meet with a ready sale here at from 6*l*. 17*s*. 6*d*., to 7*l*. per cwt. It appears that small quantities of beeswax are already exported from the Protectorate, and in view of the statement made in the descriptive report accompanying these samples that bees are extremely abundant in Nyasaland, some attempt should be made to develop this trade. It may be mentioned that about 1,000 tons of beeswax are imported annually into Great Britain.

Ginger.—The specimen of this product arrived in a damp condition, and was therefore not in a satisfactory state for valuation. It possessed, however, an excellent aroma and flavour, and the brokers to whom it was submitted stated that it would probably be worth from 32*s*. to 33*s*. per cwt. if exported in a properly prepared state.

Chemical Examination.

Tea.

The six samples of this product were grown at Mlanje and

Vegetable Products from British Central Africa.

prepared without the aid of machinery. Unfortunately, owing to the samples having been packed along with tobacco, the true aroma of the tea was masked by that of tobacco.

The samples were chemically examined in the Scientific and Technical Department of the Imperial Institute, and the results of that examination are given in the following table:—

Number.	Description.	Moisture.	Ash.	Caffeine.	Tannin determined by Eder's method.	Soluble Extract.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	“Orange ...	8 26	5·03	3·68	10·5	26·5
4	Pekoe” ...	7 84	5·28	3·54	10·4	25·4
2	“Broken...	8 32	5·09	3·35	9·5	23·7
6	Mixed” ..	7·77	5·60	3 22	9·8	23·0
3	“Dust ...	8·58	5·20	3 08	10·3	29·6
5	Fannings”	8·43	5·17	3·19	10·6	28·8

These results show that the samples of tea are of good quality. The percentages of ash and soluble extract are, however, somewhat lower than those yielded by the best Indian and Chinese teas.

The samples were submitted to a leading firm of brokers for commercial valuation. They reported that the value of the teas could only be judged from their appearance since, as has been already stated, their flavour was masked by that of tobacco. The infused leaves were moderately bright, and, in the two “Broken Mixed” and the two “Orange Pekoes,” the leaf appeared to have been fairly well manipulated, and contained a small quantity of tips. The following values were assigned to the samples:—

No. 1. ...	“Orange Pekoe,” ...	about 7*d.* per lb.
No. 4. ...	” ...	” 7½*d.* ”
No. 2. ...	“Broken mixed” ...	” 6½*d.* to 6¾*d.* per lb.
No. 6. ...	” ...	” 7*d.* to 7¼*d.* ”
No. 3. ...	“Dust fannings” ...	” 5½*d.* ”
No. 5. ...	” ...	” 5¼*d.* ”

Tobacco.

These samples consisted of two specimens of tobacco leaf, and three varieties of manufactured tobacco, the latter being described as (*a*) “pipe tobacco,” (*b*) “cigarette tobacco,” and (*c*) “smoking mixture.”

One of the samples of tobacco leaf (No. 3) was grown at Mlanje. It consisted of (*a*) rougher leaves which were in good condition, of uniform colour, with a length of 20 inches and a width of 8 inches, and probably suitable for the manufacture of pipe tobacco; and (*b*) smooth thin leaves of a uniform medium brown colour, length 17-19 inches, and width 7-10 inches, suitable for the manufacture of cigars.

The other sample of tobacco leaf (No. 4) consisted of leaves 20-24 inches long, 7-10 inches wide, medium brown in colour and badly cured, being marked with green patches and white spots.

The following table gives the results of the chemical analysis of these samples of tobacco leaf in the Scientific and Technical Department of the Imperial Institute:—

—	Percentages calculated on the dried material.		
	Tobacco No. 3.		Tobacco No 4
	(*a*) Pipe leaf	(*b*) Cigar leaf.	
Moisture (at 100° C)	10·05	9·91	10·11
Total ash	19·36	18·49	19·64
Pure ash (free from carbon and silica) ..	18·22	17·92	18·02
Silica...	0·82	0·26	1·08
Nicotine (by Kissling's method)... ..	4·7	3·9	5·9
Starch and sugar	Nil.	Nil.	Nil.
Acidity	Neutral.	Neutral.	Faintly alkaline.

These results correspond closely with the average figures obtained for American tobaccos, and indicate that, so far as chemical composition is concerned, the tobaccos are of good quality. The small proportion of silica in the ash shows that the leaves contained little or no sand.

Samples of these leaf tobaccos, together with the results of the chemical examination, were submitted to a leading firm of tobacco manufacturers. They reported that the commercial values of the tobaccos could only be determined with any approach to accuracy by testing a quantity of not less than 25 to 50 lb. The colour was regarded as fairly satisfactory, and the texture of the leaf was stated to resemble that of certain American tobaccos, although its burning quality did not appear to be so good as that of Kentucky tobaccos. If, however, proper methods of cultivation and curing are adopted, it is not anticipated that there would be much difficulty in finding a market for these tobaccos. In order to develop this trade with the United Kingdom, it would be necessary to ship a few bales of the different grades so that manufacturers might have an opportunity of testing the different qualities of the tobacco on a commercial scale.

Rubber.

Vegetable Products from British Central Africa.

In the accompanying report it is stated that "the exhibit of rubber is one of good quality, obtained from the vines of the indigenous Landolphias." The specimen itself was labelled as follows: "Rubber as collected and offered for sale by the natives of British Central Africa."

The sample weighed about 4 lb., and consisted of small hemispherical pieces, ranging up to 1¼ inches in diameter, which were evidently balls of rubber cut in two to facilitate drying. The balls had been formed by winding narrow strips of rubber on a central mass. The external colour varied from light to dark reddish-brown, the flat surface usually presenting a mottled appearance, and some of the pieces showed a white moist centre when cut open. The rubber appeared to be of good quality; it was free from stickiness and exhibited good elasticity and tenacity. A small quantity of extraneous vegetable matter, chiefly pieces of bark, was present.

As some of the pieces were considerably darker than others, two separate samples were selected for analysis:—

A. Light coloured pieces.
B. Dark coloured pieces.

These gave the following results on analysis:—

—	Sample as received.		Calculated for dry material.	
	A. Light	B. Dark.	A. Light.	B. Dark.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	1·5	1·3	—	—
Caoutchouc	87·5	89·7	88·8	91·0
Resin	4·7	4·8	4·8	4·8
Dirt	6·3	4·2	6·4	4·2
Ash included in dirt	0·6	0·8	0·6	0·8

These results show that the light and dark coloured pieces are practically identical in composition and are of good quality, the percentage of resin being low.

Samples of the rubber have been submitted for commercial valuation to brokers, who were informed of the results of the chemical examination. They describe the rubber as good, clean ball, and value it at 3s. 2d. to 3s. 3d. per lb. on the London market.

This rubber from British Central Africa is already well known in commerce, but it was thought that it would be interesting to submit the sample to chemical examination, so that its composition might be recorded for future reference.

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FIBRES.

Furcræa gigantea.

Furcræa gigantea, the plant from which Mauritius hemp is derived, is stated in the accompanying descriptive report to have been introduced into British Central Africa and found to grow well there.

This sample of the fibre was supplied by the Scientific Department at Zomba. It was clean, fairly white in colour, and had a staple about 40 inches in length.

The results of its chemical examination in the Scientific and Technical Department of the Imperial Institute are given in the following table, and are there compared with those obtained with specimens of the fibre of *Furcræa gigantea* received from Southern India, Grenada, and Victoria.

——	B. C. A. sample.	S. Indian sample.	Grenada sample.	Victoria sample.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	8·7	9·8	10·2	11·6
Ash	1·1	—	2·4	2·3
Loss on (*a*) hydrolysis	10·0	12·4	14·9	13·0
„ (*b*) hydrolysis	14·5	14·5	22·0	23·5
„ acid purification	1·7	1·7	3·8	5·6
„ mercerisation	8·7	11·4	16·0	16·2
Gain on nitration	38·1	40·7	34·0	34·0
Cellulose	75·8	77·7	77·8	72·2
Length of ultimate fibre in mm...	2—5 (average 3·5)	2—5	1—5	1—3

It is evident from these results that this sample of fibre is of excellent quality. In its chemical behaviour and composition it closely resembles the specimen from Southern India, whilst it is distinctly superior to those from Grenada and Victoria. It is less susceptible to the action of alkali than any of the other samples as shown by the smaller losses sustained on mercerisation and hydrolysis, and it is therefore in a more useful and durable condition.

Representative specimens of this fibre have been submitted to brokers for commercial valuation. They report that the fibre is clean, of fair strength and colour, but rather short, and is worth from 26*l*. to 30*l*. per ton.

Sansevieria cylindrica.

This plant is said to occur in all parts of the Shiré Highlands, but most abundantly at Mlanje, where it grows vigorously.

This sample of the fibre was supplied by Mr. H. Brown, of Mlanje. It was of a pale yellowish colour and fairly clean, but

Vegetable Products from British Central Africa.

was rather coarser than the Furcræa fibre and not so strong. Its staple had an average length of 5 ft. 3 in.

In the following table the results of its chemical examination in the Scientific and Technical Department of the Imperial Institute are compared with those of the fibres of other species of Sansevieria, which have also been examined in this Department:—

——	*Sansevieria cylindrica.* from B. C. A.	*Sansevieria zeylanica.* from Assam.	*Sansevieria zeylanica.* from Grenada.	*Sansevieria guineensis.* from Sierra Leone.
	Per cent.	Per cent	Per cent.	Per cent.
Moisture	11·4	9·4	9 5	10·6
Ash	1·6	0·7	1·4	0·4
Loss on (*a*) hydrolysis ...	18·8	11·8	11·9	8·9
" (*b*) hydrolysis ...	27·7	14·9	17·2	13·9
" acid purification ...	2·75	1·4	0·8	1·8
" mercerisation ...	7·9	11·6	14 5	8·6
Gain on nitration	35·7	33·5	28 6	29·6
Cellulose	79·1	75 6	72·7	78·0
Length of ultimate fibre in mm.	3—6·5 (average 4·7)	1·6—3·5	1—5	1·5—5

These figures show that in certain points, viz., percentage of cellulose and length of ultimate fibre, this sample of the fibre of *Sansevieria cylindrica* is superior to those of the other species examined. It is, however, more readily attacked by alkaline hydrolysis and is, therefore, likely to be less durable.

The brokers report that the sample has not been well prepared and is of uneven strength, but that, if properly prepared, its average market value would be about 25*l.* per ton. A second sample of this fibre, more carefully prepared, should be sent to the Imperial Institute for examination and valuation.

Beeswax.

Three specimens of beeswax were forwarded, two of which represent the product as offered for sale by the natives, whilst the third is a clarified sample. It is stated that bees are extremely abundant in Nyasaland, and beeswax already figures among the exports, but that much larger quantities could be readily produced.

The clarified sample was selected for commercial valuation. It was in the form of thin circular cakes, about 6 in. in diameter, and from a quarter to three-eighths of an inch in thickness, and was quite free from visible impurities. The brokers report that they consider it to be a genuine specimen of purified beeswax, and that consignments of similar quality would meet with a ready sale in the London market at prices from 6*l.* 17*s.* 6*d.*

to 7*l.* per cwt. They recommend that the wax should be shipped in blocks of 90 to 100 lb. each, cased in gunny, as such packages are preferred by buyers in this country.

It is evident from this report that clarified beeswax from British Central Africa will fetch good prices in the London market, and there is no reason why the exports of this product should not be largely increased.

Ginger.

It is stated in the report that small quantities of ginger are met with at several estates in British Central Africa, but that no attempt has yet been made to grow it upon a commercial scale. Ginger could be easily cultivated in the country, however, and as its preparation for the market involves little trouble it was thought that a price of 30*s.* to 60*s.* per cwt. would be sufficient to induce planters to take the matter up.

The specimen of ginger submitted did not arrive in a very suitable condition for commercial valuation. It was very moist and soft, and probably had not been dried sufficiently before packing. It possessed a very good aroma, however. The best pieces were selected and were submitted to brokers, who were asked to indicate as far as possible the probable value of the ginger if in good condition. They report that ginger must be quite dry in order to be saleable in the London market, and think that the value of the sample, if properly dried, would be about 32*s.* or 33*s.* per cwt.

In view of this report it is desirable that a larger sample should be collected and forwarded for further examination and valuation. Care should be taken to thoroughly dry the sample before despatch. It would then be possible to determine the precise value of the product.

Gum.

This material is stated in the accompanying descriptive report to be collected by the natives from several different trees which have so far not been identified.

The sample consisted of about 1 lb. of small fragments of translucent gum, varying in colour from light yellow to deep brown. It had a slight odour of acetic acid, but possessed no peculiar taste.

On analysis the following results were obtained:—

	Per cent.
Amount soluble in water	32·8
Moisture	15·6
Ash (magnesium and calcium carbonate with a trace of ferric oxide)	2·57

The portion of the gum insoluble in water swelled up into a translucent jelly in contact with this liquid.

Vegetable Products from British Central Africa.

This gum resembles those obtained from the Indian tree *Cochlospermum Gossypium* and the Australian plant *Sterculia acerifolia* in being only partially soluble in water and in slowly evolving acetic acid when exposed to the air. A number of gums of this type are at present being investigated in the Scientific and Technical Department of the Imperial Institute, with a view to the discovery of a commercial method of utilising them.

Insoluble gums of this class have at present no commercial value unless they can be obtained, like the well-known insoluble tragacanth gum, almost free from colour.

COTTON.

Two samples of cotton were received for examination.

One of these samples (No. 11) was supplied by the British Central Africa Scientific Department, and is said to have been grown in the vicinity of Zomba. It was somewhat harsh, of a yellowish colour, with occasional buff-coloured stains, contained fragments of broken seeds together with a few whole seeds, and had a staple 24 to 32 mm. in length.

The other sample consisted of wild cotton from North-Eastern Rhodesia, and was supplied by the British South Africa Company. It was fairly silky, had a staple of 23–33 mm., and had not been ginned. Its colour was uneven and varied from white to yellowish, with occasional buff-coloured stains.

Both samples have been submitted to brokers for commercial valuation.

With regard to the specimen from British Central Africa, it is reported that the cotton is perished wherever the reddish stains occur, and that the staple, although of fair length, is irregular and coarse. Its value is given at about 5*d.* per lb. on the spot.

The specimen of wild cotton from North-Eastern Rhodesia is also said to be perished where stained. It is probably worth about 4½ lb. on the spot.

The brokers add that the above valuations are based on the assumption that the seeds would be removed and the cotton properly cleaned. They state that the seed itself, freed from the cotton, would probably be worth about 4*l.* 5*s.* per ton.

HEMP AND COTTON FROM SOUTH AUSTRALIA.

These samples, consisting of Sisal hemp, bowstring hemp, Mauritius hemp and cotton were forwarded by the South *Australia Chamber of Manufactures (Incorporated) to the Commercial Intelligence Branch of the Board of Trade*, and were transmitted to the Imperial Institute for examination and valuation.

The samples have been examined in the Scientific and Technical Department of the Imperial Institute, and have also been submitted to leading firms of brokers for commercial valuation. The samples of hemp were too small to admit of a complete chemical examination being carried out.

Sisal Hemp (*Agave rigida* var. *sisalana*).

This sample consisted of white, strong fibre with a staple of average length, 40 inches. On chemical examination it furnished the following results:—Moisture, 8·8 per cent.; ash, 0·7 per cent.; cellulose, 79·1 per cent. A comparison of these results with those yielded by specimens of Sisal hemp cultivated in other Colonies and already examined in the Scientific and Technical Department, is given in the following table:—

Source.	Moisture per cent.	Ash per cent.	Cellulose per cent.
South Australia	8·8	0·7	79·1
Bahamas	12·8	4·4	75·9
Trinidad	11·6	1·0	77·2
New South Wales	9·8	1·6	77·7
India (Saharanpur)	9·1	0·8	82·4

From these figures it is seen that the present specimen furnished a low proportion of ash and a high proportion of cellulose; it is, therefore, of good quality and likely to be durable.

The brokers reported that the fibre was of good length and colour, fairly strong, and worth from 35*l.* to 38*l.* per ton on the London market.

Bowstring Hemp (*Sansevieria zeylanica*).

This specimen was clean, of good colour, and had an average length of 38 inches. It yielded the following results on chemical analysis:—Moisture, 8·1 per cent.; ash, 0·4 per cent.; cellulose, 80·9 per cent. In the following table these results are compared with those furnished by specimens of this fibre grown in other Colonies which have been examined at the Imperial Institute:—

Source.	Moisture per cent.	Ash per cent.	Cellulose per cent.
South Australia	8·1	0·4	80·9
Assam	9·4	0·7	75·6
Grenada	9·5	1·4	72·7
Straits Settlements	9 9	0·7	75·9

Hemp and Cotton from South Australia.

These numbers show that the present sample yields a very low percentage of ash, and contains an unusually large proportion of cellulose, and on these grounds is to be regarded as of good quality.

The brokers reported that it was a soft, fine fibre, but somewhat deficient in strength, and of the value of 33*l.* to 35*l.* per ton.

Mauritius Hemp (*Furcræa gigantea*).

This sample was of fair colour, but had not been so carefully prepared as the two preceding samples; its staple was about 5 ft. in length. The results obtained on chemical examination were as follows:—Moisture, 8·5 per cent.; ash, 1·4 per cent.; cellulose, 74·5 per cent. In the following table these figures are compared with those yielded by specimens of Mauritius hemp from other countries which have been examined in the Scientific and Technical Department of the Imperial Institute.

Source.	Moisture. Per cent.	Ash. Per cent.	Cellulose. Per cent.
South Australia	8·5	1·4	74·5
Southern India	9·9	—	77·7
Grenada	10·2	2·4	77·8
Victoria	11·6	2·3	72·2
British Central Africa	8·7	1·1	75·8

In this case the cellulose is somewhat below the average, and, on this account, the fibre is probably of a less durable character. The brokers reported that the fibre is very long, but of poor colour, roughly prepared and weak. Its value on the London market is from 28*l.* to 30*l.* per ton.

Cotton (*Gossypium barbadense*).

It is stated that this specimen is probably of the "Sea Island" variety, but that its quality is inferior since the plants from which it was gathered were several years old and their cultivation had been neglected. The sample was clean and white, and the length of staple 1·2 to 1·5 inches.

The brokers reported that the cotton was silky, but irregular, and that it was inferior to American "Sea Island" cotton. It was regarded as worth about 7½d. per lb. at the present time.

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COTTON FROM NORTH-EASTERN RHODESIA..

These samples of cotton, grown near Mirongo Station, in the Senga country, were received by the British South Africa Company from the Administrator of North-Eastern Rhodesia, and were transmitted to the Imperial Institute for examination and commercial valuation.

They have been examined in the Scientific and Technical Department of the Imperial Institute, and have given the following results:—

No. 1. *Labelled,* "*Mirongo-Senga, June,* 1903."—This sample was of creamy colour with a faint reddish tinge, the staple was soft, silky, and of good length (1·2—1·4 inches). The cotton was valued by brokers at 7⅝d. to 8d. per lb. (February, 1904).

No. 2. *Labelled,* "*Katumbi-Senga, June,* 1903."—This cotton was of good creamy colour, but the staple, though of fair length (1·3–1·5 inches), was weak and irregular. This sample was valued at 7⅜d. to 7½d. per lb. (February, 1904).

No. 3. *Labelled,* "*Mirongo-Egyptian, June,* 1903."—This specimen was silky, soft to the touch, and of a pale reddish-brown colour. It was not so strong as this cotton grown in Egypt, the staple was rather irregular, and its length was 1·3–1·5 inches. The sample was valued at 8½d. per lb. (February, 1904).

No. 4. *Labelled* "*Katumbi-Egyptian, June,* 1903."—This cotton resembled No. 3, but was rather paler in colour; the staple was "neppy," less silky than that of No. 3, and had a length of 1·3–1·5 inches. It was valued at 8¾d. per lb. (February, 1904).

These results indicate that these cottons are of good quality, and that their cultivation in North-Eastern Rhodesia is likely to prove successful

A SUPPOSED KAURI RESIN FROM QUEENSLAND.

This sample of resin was forwarded to the Imperial Institute by the Agent-General for Queensland with the request that its commercial value might be ascertained. In the letter accompanying the sample it was stated that the material was "thought to be a species of Kauri," and that it was obtainable in fair quantities in Queensland. The resin has been examined in the Scientific and Technical Department of the Imperial Institute and has given the following results:—

The sample consisted of a single rounded block, weighing about three pounds, composed of a bright yellow transparent resin, with a number of dark streaks and opaque patches scattered throughout its mass. The material had a pleasant, aromatic odour, especially when freshly broken. It was almost completely soluble in alcohol and ether, slightly soluble in benzene, and very slightly so in chloroform.

The specific gravity of the resin was 1·0543, it furnished on ignition 0 13 per cent. of ash, and its acid number was 136·6.

These results indicated that the material was quite different from New Zealand Kauri resin, since the latter is only partially soluble in alcohol and ether, and in general has an acid number in the neighbourhood of 101.

No information regarding the botanical origin of the Queensland product was forwarded with the sample, but the similarity in the chemical properties of this material to those of the resin known commercially as "Australian sandarac" indicated that these two products might have a common origin. Australian sandarac occurs in commerce in the form of small light yellow tears, and is obtained from various species of *Callitris*, the most important of these being *Callitris calcarata* and *Callitris verrucosa*.

This similarity of the Queensland resin to Australian sandarac is shown by the following comparative statement of the principal constants of the two resins:—

—	Specific gravity.	Acid Number.	Solubility.
Queensland resin	1·0543	136·6	Soluble in alcohol and ether
Australian sandarac	1·060	135·8	" " "

The chemistry of the resin of *Callitris verrucosa* was made the subject of a special investigation in the Scientific and Technical Department of the Imperial Institute in 1901, the results of which were published in the "Journal of the Chemical Society," 1901, p. 1,144, and this work has now been repeated on the

A supposed [illegible] from Queensland.

Queensland resin. The quantity of the latter sent for examination was too small to permit of an exhaustive investigation of its constituents, but conclusive evidence has been obtained that, like the resin of *Callitris verrucosa*, it consists essentially of pimaric and callitrolic acids. It may, therefore, be assumed provisionally that the Queensland resin is derived from a species of *Callitris*, and that it may be regarded as a sandarac.

Commercial valuation.

Sandarac resin is principally employed in the manufacture of varnishes. For this purpose African sandarac obtained from *Callitris quadrivalvis* is regarded as the best of the commercial varieties, and is worth from 60*s*. to 70*s*. per cwt. Australian sandarac, which is stated to be principally obtained from New South Wales, occasionally appears on the English market, and recently, owing to a scarcity of the African product, has been in slight demand at about 35*s*. per cwt.

The African and Australian sandaracs so far met with in commerce occur in characteristic, elongated, light yellow "tears" quite different in appearance from the large block form in which the Queensland resin was sent. The latter, owing to its unusual form, would probably not be saleable at quite so high a price as the ordinary "tear" form of Australian sandarac, and at first it is unlikely that more than 25*s*. to 30*s*. per cwt. could be obtained for it.

It may be pointed out that there is practically no difference in composition between the Australian and African sandarac resins, and that the lower prices obtained for the former are to be ascribed principally to the irregularity and deficiency of the supply from Australia and the consequent want of knowledge of this product among manufacturers using sandarac in this country.

PODS OF *CÆSALPINIA CORIARIA* ("DIVI-DIVI") FROM INDIA.

This sample of the pods of *Cæsalpinia coriaria*, known commercially as "divi-divi," and employed as a tanning material, was received at the Imperial Institute from the Officiating Reporter on Economic Products to the Government of India, and has been examined in the Scientific and Technical Department of the Imperial Institute as a part of the general investigation of Indian tanning materials now being carried out.

Two samples, Nos. 8026 and 8028, of Indian "divi-divi" have already been examined in this Department, and the results of that examination are published in the volume of Technical Reports and Scientific Papers (p. 191) recently issued by the Imperial Institute

Pods of Caesalpinia coriaria ("Divi-Divi") from India.

Chemical Examination.

The present sample, No. 18,545, weighed about one pound, and consisted principally of husks with a few small unbroken fruits containing one or two minute black seeds. The husks were brown in colour; they were from one to two inches in length, and were usually curled into broken irregular flattened spirals. The sample presented on the whole the appearance characteristic of the "divi-divi" of commerce.

The material was chemically examined in the usual manner and gave the results shown in the following table, which also contains for convenience of comparison the results obtained in the Scientific and Technical Department with the two samples of Indian "divi-divi" previously examined, and with a specimen of this tanning material received from Queensland in 1898.

"*Divi-divi*" *pods.*

	Indian samples			Queensland sample.
	No 18,545	No. 8,026.	No 8,028.	
Tannin (calculated on the material dried at 105° C.	45·4	19·7	32·8	51·4
Total soluble matter	68·5	65·9	46·0	68·3
Moisture...	13·3	12·8	13·1	15·9
Ash*	2·6	3·1	3·3	2·2

* *Principally calcium carbonate with a little ferric oxide and silica.*

It will be seen that the present sample of "divi-divi" is of much better quality than either of the previous India samples, containing, as it does, more tannic acid and more matter soluble in water.

It may be added that the aqueous extract obtained from the pods was of a pale brown colour, and would probably furnish a leather of a satisfactory light colour, but the sample supplied was insufficient to permit of the investigation of this point.

The "divi-divi" of commerce is principally obtained from South America, and contains on the average from 40 to 45 per cent. of tannin. The commercial value of such material at present is from 8*l.* 10*s.* to 11*l.* per ton, and it is probable that Indian "divi-divi" of the same quality as the present sample would sell readily at this price.

"MPAI" RUBBER FROM AMATONGALAND, NATAL.

This sample of rubber was forwarded to the Imperial Institute for examination in the Scientific and Technical Department.

The rubber was labelled "'Mpai' rubber, sample No. II., A. and M. 3839/1903," and had been obtained from Maputa, Amatongaland. In a minute by the Conservator of Forests, a copy of which was supplied, it is stated that the rubber is believed to be the product of a Ficus, the species of which has not yet been determined. The plant, however, is said to be identical with the tree referred to by the Amatongaland Rubber Commission under the native name "Mfubu." The Commissioners reported that this tree is only found in the heavily timbered swamps along the coast, principally around Kosi Bay, and they were of opinion that it would probably prove to be a most valuable rubber tree.

It is desirable, therefore, that steps should be taken to determine the botanical identity of this tree, which is known by the two names, "Mpai" and "Mfubu."

It is pointed out by the Conservator that this Ficus is not the only rubber tree in Amatongaland, as Landolphias and other rubber-yielding plants occur there. The Scientific and Technical Department of the Imperial Institute has already examined and reported on two samples of rubber from the Maputa district, but no information was supplied regarding the botanical origin of these specimens, nor were they described by vernacular names. They were quite different in character, however, to the present specimen.

The sample of "Mpai" rubber submitted for examination consisted of a flat, elongated cake which weighed about 35 grams. It was light-brown externally, but the freshly-cut surface was less coloured and showed a pinkish tinge. The material could be easily indented with the finger nail, and exhibited very little elasticity but considerable tenacity; it had a somewhat fibrous structure, resembling that of gutta percha. When placed in warm water it softened a little without becoming sticky, and could then be readily drawn out to a considerable length, but the elasticity was only very slight.

The physical properties of the material seem to be intermediate between those of true rubber and gutta percha, a common feature of the products yielded by species of Ficus, but in composition, as shown by the analysis recorded below, it is much more closely related to rubber.

"Mpa" Rubber from Amatongaland, Natal.

The chemical examination furnished the following results:—

	Sample as received. Per cent.	Calculated for dry material. Per cent.
Moisture	28·4	—
Resin	49·9	69·6
Caoutchouc	19·6	27·4
Dirt	2·1	3·0
Ash included in dirt	0·79	1·10

The material, therefore, consists principally of resinous substances, which form 69·6 per cent of the dry material, whilst only 27·4 per cent. of true caoutchouc is present. The isolated caoutchouc was not very strong, but was quite free from stickiness.

The sample was submitted for commercial valuation to brokers, who were informed of its chemical composition. They report that the material would be suitable for certain technical purposes, and that sales could probably be effected at about 10½*d.* or 11*d.* per lb.

RUBBER OF *LANDOLPHIA KIRKII* FROM AMATONGALAND, NATAL.

Two samples of rubber prepared in Amatongaland from the "Ibungu" vine, *Landolphia Kirkii,* were forwarded to the Imperial Institute, and a report upon their composition and commercial value was requested. It was stated that this rubber is being collected in some quantity at the present time.

The specimens received for examination consisted of two half-balls of rubber which were identical in appearance and general characters. They bore no distinguishing marks, and were consequently denoted A and B to facilitate reference. The balls were light pinkish-brown externally, but were deep reddish-brown within. The rubber was quite dry, and only contained a small amount of foreign vegetable matter; it was not sticky, and exhibited very good elasticity and tenacity.

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Rubber of Landolphia Kirkii from Amatonga-land, Natal.

The chemical examination in the Scientific and Technical Department of the Imperial Institute furnished the following results:—

—	Sample A.		Sample B.	
	As received.	Calculated for dry material.	As received	Calculated for dry material.
	Per cent	Per cent.	Per cent.	Per cent.
Moisture	7·7	—	9·1	—
Caoutchouc...	80·1	86·8	75·7	83·3
Resin	6·9	7·5	10·3	11·3
Dirt	5·3	5·7	4·9	5·4
Ash included in dirt ...	0·31	0·33	0·37	0·40

These analyses show that so far as chemical composition is concerned the rubbers are of good quality, especially sample A, which contains a very much lower percentage of resin than B. This variation in the amount of resin was the only difference which could be detected between the two samples. Both had evidently been carefully prepared, and their physical characters were exceedingly good. In composition they compare very favourably with other samples of rubber derived from *Landolphia Kirkii* which have recently been examined at the Imperial Institute.

The rubbers were submitted for valuation to brokers who report that consignments represented by these specimens would command a very ready sale, and would probably realise as much as 4*s.* per lb. in the London market at the present time, when fine Para rubber is quoted at 4*s.* 8*d.* per lb.

Bulletin of the Imperial Institute.

GENERAL NOTICES RESPECTING ECONOMIC PRODUCTS AND THEIR DEVELOPMENT.

THE PRINCIPAL PETROLEUM RESOURCES OF THE BRITISH EMPIRE.*

Part II. INDIA.

The existence of mineral oil at various points in extra-peninsular India and the immediately adjoining areas was well established for many years before serious efforts were made to work the deposits on a large scale and according to European methods. It must be remembered, however, that the oil-fields of Upper Burma, which are by far the most important, were not included in the political limits of India till the annexation of the country in 1886.

Until comparatively recently there was only a very limited demand for petroleum in India since vegetable oils were almost universally used for illuminating purposes. The last thirty years have, however, witnessed a remarkable growth in the consumption of this commodity, and both imports and production have increased rapidly.

In the financial year 1875-1876 (terminating on the 31st of March), which is the first for which import statistics are available, the imports amounted only to 621,580 gallons, and the entire produce of India and Upper Burma cannot have much exceeded two million gallons, some of which was exported. In 1884-5 the imports from over sea had risen to 27,306,999 gallons, the local production for the same year exceeding two million gallons.

The imports of oil into India were at first principally of American origin, but in recent years Russian petroleum has been imported in increasing quantities.

Since 1890 the amount of crude mineral oil produced in the different provinces of India has been published in the "Statistics of Mineral Production" in India. The figures for the period 1897–1902 are given in the accompanying table: —

Production of Mineral Oil in India, 1897-1902.

Production in	1897.	1898.	1899.	1900.	1901.	1902.
Burma ...	18,875,530	18,424,408	32,309,531	36,974,288	49,441,784	54,848,980
Assam ...	222,077	547,965	623,372	758,049	631,571	1,756,759
Punjab ...	2,041	1,510	1,104	1,874	1,812	1,949
Total ...	19,099,648	18,973,878	32,934,007	37,729,211	50,075,177	56,607,688

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* PART I. *of this article, dealing with the petroleum resources of Canada appeared in the Imperial Institute Bulletin, Vol. I.*, 1903, *p.* 133.

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The annual production in India has therefore increased from less than nineteen million gallons in 1897 to over fifty million gallons in 1902, but nearly two-thirds of the total amount of petroleum consumed in the country is still supplied from abroad. The amount contributed by Burma is far in excess of the produce of the rest of India, though the output of Assam is beginning to assume importance.

UPPER BURMA.

Nearly the whole of the Indian supply of mineral oil has been and still is obtained from an area of about 350 acres lying a mile and a half to the east of Yenangyoung, on the River Irrawadi. The country forms a plateau rising to about 260 ft. above the level of low water in the river and intersected by ravines which are sometimes as much as a hundred feet in depth. The strata are probably of Miocene age. They form an anticlinal whose axis runs north 30° west, and south 30° east, sloping gently down in each direction so that the structure of the country is that of an elongated dome. The surface is formed by sandy beds known as the Yenangyoung series, having a thickness of fifty or a hundred feet and containing no oil. Below them is an alternation of clays and sands the total thickness ot which is unknown ; it is from these interstratified sands that the oil is obtained, most of it at a depth of from 200 to 350 ft.

There were two areas worked by the Burmese, that to the south near the village of Beme is already approaching exhaustion ; the other, close to Twingong, is still yielding well. The intervening ground was believed by the native workers to be barren, but many of the wells which have been drilled near Khodaung have proved to be highly productive.

Wells were first drilled by modern methods in 1887, soon after the annexation. Those which were successful yielded from a hundred to a thousand gallons a day ; none of them flowed at the surface.

The oils from the Yenangyoung field are of a dark greenish colour when examined by reflected light and are almost opaque to transmitted light. The character of the oil varies greatly from well to well, the specific gravity ranging from 0·860 to 0·956.

There are two principal varieties, one with high specific gravity and viscosity, and a melting point of about 80° F., but containing scarcely any solid hydrocarbons, while the other has a comparatively low specific gravity and contains a large proportion of solid paraffin.

Mineral oil is also found at Yenangyat, eight miles south of Pagan and fifty-four miles north-north-west of Yenangyoung on the opposite side of the Irrawadi, where there is a similar but sharper synclinal. The wells worked by the Burmese in this field are shallow and yield little oil. After the annexation wells were drilled in this field also, and in one case a yield of 175 gallons a day was obtained. In 1898 there were 17 wells in this field. A considerable amount of gas is met with. Some of the wells flowed at the surface when oil was first struck, and in two cases they continued to do so. The oil has a specific gravity of about 0·823, and contains a considerable amount both of the solid and of the more volatile liquid hydrocarbons.

Oil also occurs at Minbu, about 18 miles below Yenangyoung, where there are mud volcanoes. Other localities in Upper Burma are the Yaw country west of Pagan, the Chindwin Valley north of the same place, and Indwin, some 50 miles inland from this.

Though used occasionally for illuminating purposes, the oil obtained in Upper Burma was in former times mainly employed for preserving wood. Sometimes it was taken as a medicine, or was applied externally for skin diseases.

It is difficult to obtain satisfactory statistics of the output of Upper Burma previous to the annexation. The estimates of travellers who visited the Yenangyoung field from time to time are very conflicting, varying from about 573,000 gallons (2,300 tons) per annum, to 23,000,000 (93,000 tons). It is improbable that the total produce of Upper Burma ever reached 3,000,000 gallons.

Even before the annexation a considerable amount of oil was sent down the river to Rangoon. Much of this was shipped to Europe, where it was known as Rangoon oil, and was employed for lubrication and the manufacture of paraffin candles. At the same time solid paraffin, which had been formed naturally from the evaporation of the more volatile constituents, was exported in the form of candles and ornaments.

The oil was formerly used in India and exported to Europe in its crude state, but in 1870 a refinery was erected at Rangoon. Owing, however, to political difficulties, the raw material could not be obtained from Upper Burma in sufficient quantities to make the enterprise a success.

In 1878-9 only about 526,000 gallons were imported. In 1885-6 the amount had risen to 1,537,000 gallons, and in 1888-9 to 2,521,000 gallons. This was the last year in which returns were made of the trade between Upper and Lower Burma. Shortly after the annexation the Burma Oil Company was formed and erected a factory at Rangoon, where oil from Upper Burma is refined in large quantities, the illuminating oil produced being sold in the country and the solid paraffin exported to Europe.

LOWER BURMA.

A few oil-bearing localities occur in the Irrawadi division to the south of, and more or less in a line with those of Upper Burma. In 1888 there were two wells in the Thayetmyo district which were being worked, and produced 970 gallons a year. This oil was viscous oil of Upper Burma, and was said to be used for varnishing boats. Oil is also found near Prome and at Yenangdoung in the Henzada district.

The most important oil-fields of Lower Burma are those of the Arakan Islands. Oil has been found in the Northern Islands, Akyab and eastern and western Baranga. It occurs in the large island of Ramri, at Likmau and Minbyin on the west coast, at Letaung in the south-west, and Kyauk Phyu on the north and also in the adjoining island of Cheduba. The oil-fields are characterised by numerous mud volcanoes due to the action of the gaseous hydrocarbons associated with the oil. Petroleum, mud and stones are ejected with the gas. The strata consist of lignite-bearing sandstone and shales probably of Upper Eocene age.

The oil has long been collected by the inhabitants between the end of the harvest in January and the commencement of the rainy season The yield was, however, very small, the total not reaching five hundred thousand gallons a year. In some cases the oil rises rapidly into the wells, accompanied by gas; in others it slowly filters in.

About 1877 two wells were sunk in eastern Baranga to a depth of 30 ft, and boring was then commenced. At a depth of 66 ft. from the surface there was an outburst of oil and gas; the one well yielded about 7,000 gallons in the first week and afterwards 120 gallons a day: the other yielded 150 gallons a day after the first outburst Great efforts have since been made to exploit the oil deposits in these islands. In 1888 there were 38 wells worked by modern methods near Minbyin, some of them under Canadian experts.

The annual production, however, only amounted to 86,728 gallons.

At that time there were numerous wells worked by Arakan merchants, 45 near Letaung and 124 in the island of Cheduba, the total output being 61,816 gallons per annum. There were also six wells in East Baranga, under European management, which produced 70,000 gallons per annum In the whole Arakan district there were in 1888 43 wells sunk according to modern methods which were yielding oil, seven were incomplete and at least 108 had been abandoned as useless.

The development of this district has since been continued by

The Principal Petroleum Resources of the British Empire.

an Australian company, and good results are stated to have been obtained.

Much of the Arakan oil has the appearance of sherry, and can be burnt in lamps in its crude state. The specific gravity varies from 0·835 to 0·888, and some of the oil contains as much as 66 per cent. of kerosene of specific gravity 0·815.

ASSAM.

Petroleum is found in Assam in coal-bearing strata of Eocene age. These are exposed near the foot of the Naga Hills to the south-west of the River Brahmaputra. There is a line of outcrops on the north-western slopes of the Tipam Hills, a low range running from north-north-east to south-south-west, and intersected by the Dihing River near Jaipur, and further to the south-west by the Disang.

Another line of outcrops, known as the Makum coalfield, is met with further to the east, running east-north-east and west-south-west roughly parallel and to the south of the Dihing River. It is intersected by the Tirap, Namdang, Makum and Dirah Rivers, all tributaries of the Dihing, and then sinks below the alluvium near the Tipam Hills; some forty miles further to the south-west, the coal and oil bearing strata reappear and are exposed in the beds of the Dikhu, Tanji and Disa Rivers.

The first attempt to work the petroleum in this district was made in 1867; oil was struck at 118 ft. and rose to within 44 ft. of the surface. Altogether eight wells were sunk, which yielded 80,000 gallons in 228 days, but the flow was intermittent, not improbably on account of the presence of water. The enterprise was ultimately abandoned on account of difficulties of transport. About 20 years later, when the country had been opened up with railways, drilling operations were commenced at Digboi in the Tipam Hills north of the Dihing, as well as on the Makum coalfield, not far from the Dihing Bridge Station. Oil was found at Digboi at 400 feet, and in larger amount at a depth of between seven and eight hundred feet. The Digboi oil varies in specific gravity between 0·835 and 0·845. It contains a large amount of very volatile hydrocarbons, as well as a considerable proportion of solid paraffin. It solidifies at about 70° F. In one well a stratum of solid black paraffin was met with at a depth of 700 feet. It had a melting point of 120° F. Most of the oil differs considerably from that obtained at Digboi. It has a specific gravity of 0·944, and deposits no solid paraffin when cooled to 0° F. There is a second higher horizon which yields oil similar to that from Digboi. Some of the wells at Makum flowed for a short time at the surface. These fields continue to yield oil, and the output is increasing. The high dip of the strata must have been unfavourable to the preservation of the oil, and the beds must soon reach a depth when they are inaccessible to drilling operations.

Oil has also been observed further to the west, in strata of the same age in the southern slopes of the Khasi and Garo Hills in the angle of the Brahmaputra where it makes a sudden bend to the south.

PUNJAB.

Oil bearing strata are found among the Eocene rocks. There are two lines of outcrops running roughly east and west, one near Rawal Pindi, the other north of Shahpur.

The only locality that has been worked to any extent is Gunda or Sudkal, about 23 miles west of Rawal Pindi. Oil wells were first dug in 1861. The principal well yielded at first only 5 gallons a day; on deepening, the amount was increased, but it never yielded more than 50 gallons in one day, and in 198 days in 1870 only 1,963 gallons were obtained. About 1880 the total annual yield was rather more than 2,000 gallons. In March, 1888, a concession was granted to an American oil refiner who does not appear, however, to have been very successful. In 1889 the yield was only 2,873 gallons, which appears to be the maximum amount obtained in any one year. A limited supply of oil is still obtained. It appears to be employed in gas-making at Rawal Pindi.

BALUCHISTAN.

Petroleum occurs at various points in the Eocene beds. One locality is in the gorge of the Toi, near Moghal Kot, in the Sherani Hills to the west of Dera Ismael Khan, and twelve miles south-east of Takht-i-Suleiman. It flows from two holes which together yield about 7 gallons a day. Its specific gravity varies from 0·811 to 0·821. It is light-coloured and mobile, and was ascertained by Mr. T. H. Holland to contain about 84 per cent. of illuminating oil, but there does not seem much prospect of an abundant supply being obtained.

Petroleum also occurs in the neighbourhood of the Bolan Pass, at Khotan in the Mari Hills, forty miles east of Sibi Junction, where borings were commenced in 1884.

From the first well 5,000 gallons were obtained in 36 hours, and between April and July in 1886, 27,700 gallons of oil were sent to Sibi, where it was tried on the locomotives. In 1889, 218,490 gallons were raised, but the rains flooded the wells and nearly stopped the flow of oil, the monthly output falling from 39,000 gallons to 2,500. After heavy pumping, the yield slowly improved till in June 1890 it reached 20,000 gallons a month, but the wells were again flooded in the rainy season, and

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by the beginning of 1891 they did not yield more than enough to supply fuel for the machinery, subsequently further borings were made, and 50,000 gallons appear to have been obtained in 1894. The oil has almost the same specific gravity as water, and is very viscous owing to the large amount of bituminous matter it contains

Mineral oils and bitumens are said to be found in Afghanistan in the Shah Makhand range. It is also met with in Hazara, Kumaon and Kach, and other localities, in most cases in rocks of Eocene age, but none of these occurrences appear to be of any importance.

THE WORLD'S PRODUCTION OF NON-METALLIC MINERALS.

In view of the increasing industrial importance of the non-metallic minerals during recent years, a survey of the present sources of supply has been furnished by Mr. Bennett H. Brough in a series of four Cantor Lectures delivered before the Society of Arts ("Journal of the Society of Arts," Vol. LII., p. 113). The commercial importance of the subject is well illustrated by the enormous value which the annual production of these products has already attained. In the United Kingdom the estimated value of the output during 1901 was 111,000,000*l.*, and in the United States it was 113,000,000*l.*, being in both cases considerably greater than the value of the metallic products. The lectures include references to all the principal non-metallic minerals employed industrially or in the arts, and the information regarding the most important products has been summarised in the following account.

The first and most important class of these products includes the combustible minerals, coal and petroleum, and it will be convenient to deal separately with the principal members of this group.

Graphite.—This mineral, also known as plumbago or black lead, is chiefly found intercalated in the older crystalline metamorphic rocks, but it is only rarely that the deposits are sufficiently pure to be economically worked. The world's production in 1900 is given as 78,721 metric tons, of the estimated value of 650,000*l.*, and the three principal producing countries are Austria, Ceylon and Italy, which respectively furnished 38·0, 28·9 and 13·1 per cent. of the total. Most of the Ceylon graphite contains more than 90 per cent. of carbon, whereas not more than a quarter of the Austrian output reaches that degree of purity. The purest forms of graphite are employed for the manufacture of pencils and lubricants, whilst the

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crystalline varieties from Ceylon, Bavaria and Sweden are utilised in the manufacture of crucibles, stove blacking, paints and foundry facings.

Artificial graphite is now being manufactured at Niagara, and is beginning to compete with the natural product. In 1901 the output was 1,125 tons, valued at 2*l*. per ton, and half this was used for the manufacture of electrodes.

Coal.—The world's production of the several varieties of coal amounted in 1901 to 789,128,476 metric tons, of which the three principal producing countries, the United States, the United Kingdom and Germany contributed 33·8, 28·2 and 19·4 per cent. respectively. In 1902 the United States produced 268,688,000 tons, the United Kingdom 227,095,000 tons, and Germany 107,436,000 tons, these amounts representing 3⅓ tons, 5½ tons and 2 tons respectively per head of population in the three countries.

The principal deposits of anthracite coal are situated in Eastern Pennsylvania and in South Wales, to the west of the vale of Neath, and the present annual output from these two districts is 50,000,000 and 2,000,000 tons respectively. With reference to bituminous coal, the chief mining counties in the United Kingdom are Durham, Yorkshire and Glamorganshire. In the United States the most important coalfields are those contained in the Appalachian mountain system, which extends from Pennsylvania and Ohio to Alabama. This field furnished 66·7 per cent. of the total production in the United States. Next in importance are the portions of Illinois, Indiana and Kentucky, which make up the central coalfield. This contributed 16·6 per cent. of the total output. The western coalfield furnished 8·7 per cent., the Rocky Mountain 6·2 per cent., and the Pacific Coast 1·2 per cent. In Germany the Rhenish-Westphalian coalfield is the most extensive, whilst the largest in Europe is the Donetz coalfield in Russia.

The production of coal in the British Colonies and Dependencies is increasing year by year, and in 1901 it amounted to 21,901,873 metric tons. The chief contributors to this total were as follows: -Australia, 7,000,227 tons; India, 6,742,214 tons; Canada, 5,612,108 tons; and New Zealand, 1,247,339 tons.

The future of the British coal industry has given rise to considerable discussion, as, during the last quarter of a century, the output has not increased so rapidly as in America and Germany, and since 1899 the United States has become the premier coal-producing country. Various estimates have been given of the amount of coal still available in the United Kingdom and the probable duration of the coalfields, but no great value can be attached to these forecasts owing to the impossibility of anticipating the rate of increase in the consumption or the depth to which the mines can be successfully worked. The limit of depth adopted by Professor Hull and the Royal Coal Commission of 1870 was 4,000 feet, and at the present time the deepest mine in the United Kingdom is the Pendleton Colliery, near Manchester, where some of the workings are nearly 3,500 feet below the surface. Greater depths than this have been attained, however, in other countries. In the Lake Superior district the Red Jacket shaft of the Calumet and Hecla Copper Mine has now reached a depth of 4,900 feet, and in Belgium there is a colliery at Mons which is 3,937 ft. deep. It is evident that the mechanical difficulties attending the working of such deep shafts can be successfully overcome and the greatest obstacle is the increase in temperature with the depth. At the Paruschowitz borehole, in Silesia, which has been carried to the depth of 6,573 ft., the increase of temperature has been found to be 1° F. for every 62·1 ft. Taking this as an average, a coal seam at 4,000 ft. would be, without making any allowance for the cooling action of the ventilating current, 64° F. warmer than the ground near the surface.

Considerable attention is at present being devoted to the introduction of improved methods of mining coal, which will reduce waste, and to the possibility of effecting economy in its use. In the United States 25 per cent. of the output is obtained by mechanical coal cutters, which furnish a larger percentage of lump coal, and in the United Kingdom also there has recently been a distinct increase in the number of these machines at work. As an illustration of the economy which has been effected in the use of coal during recent years, it may be mentioned that in 1871 the iron and steel trade used 30 per cent. of the total amount consumed in the United Kingdom, whereas, in 1889, its requirements had been reduced to 16 per cent.

Brown Coal. — Under this heading are included all the varieties of coal which are intermediate between peat and the true coal of carboniferous age. The character of these coals varies with their geological age. Some specimens have a distinct ligneous structure (true lignite), others are without organic structure (earthy brown coal), while others again are black and lustrous with conchoidal fracture.

In Great Britain brown coal has been worked only in a seam of lower tertiary age at Bovey Tracey, in Devonshire. On the continent, however, brown coal is extensively mined in Austria and Germany. During 1902 the output from the former country included 18,262,592 tons from Bohemia and 2,585,233 tons from Styria; in Germany during the same year the Halle district produced 29,233,936 tons, the Cologne district 5,354,440 tons, the Kingdom of Saxony 1,635,000 tons and Upper Bavaria 24,000 tons. Considerable deposits of brown coal, which are being commercially worked at the present time, occur in Victoria, Australia, where the beds [illegible] 150 ft. thick, and in New Zealand.

Brown coal is largely employed on the continent for industrial purposes and also for domestic use in the form of briquettes. The best qualities are sometimes utilised for metallurgical operations.

Natural Gas.—In the petroleum districts of Pennsylvania and the adjoining States natural gas occurs in the strata at a depth of 500 to 2,000 ft., and when boreholes are sunk the gas rises to the surface under a mean pressure of 150 to 200 lb. per square inch. Since 1885 natural gas has been very largely utilised in the United States for industrial purposes, but no record of the amount used is kept. For generating steam, 1,000 cubic feet of the gas is equal to from 80 to 133 lb. of coal, and in 1901 the amount of coal displaced by natural gas is returned at 8,458,600 tons. In that year there were 10,297 wells in operation, with 21,848 miles of natural gas mains, and the gas was used in 1,545 establishments. In some cases the supply of gas from a well is limited, but in others no apparent diminution can be noticed after several years working.

In England natural gas has been discovered in West Sussex, near Heathfield, and is now being utilised for lighting and heating purposes. According to official statistics the production in 1902 was 150,000 cubic ft. Experimental borings are now being made in Sussex over an area of 200 square miles with a view to determine the extent of the gas field and its commercial possibilities.

Petroleum.—The petroleum industry dates only from the year 1859, but it has already attained enormous importance. The world's production in 1901 amounted to 19,940,447 metric tons, of which Russia and the United States contributed 49·2 and 44·2 per cent. respectively. Smaller supplies are obtained from Galicia, Roumania, Burma, the Dutch Indies, Japan and Canada.

Petroleum offers many advantages as a fuel, and is now being extensively used for that purpose. It is cheap, develops great heat on combustion, and is less bulky than coal, a ton of oil occupying 33 cubic ft. against 40·5 cubic ft. for a similar weight of coal. The average calorific power of the crude oil is about 10,000 calories, different varieties giving the following values:—West Virginia, heavy oil, 10,180; West Virginia, light oil, 10,223; Pennsylvania, light oil, 9,963; Ohio, heavy oil, 10,399; Java, 10,831; Roumania, 10,005; and Baku, 11,460. For illuminating purposes the Pennsylvanian oil is the best.

The [illegible] Pro[illegible] of [illegible] Metallic Minerals.

[illegible] world's largest petroleum field is situated in Russia, to the north of Baku on the Caspian, and during 1902 it produced 11,000,000 tons of crude oil. About 200 boring derricks are at work there at the present time and the bore holes have an average depth of 200 yards, though some of them reach 500 yards.

No petroleum is obtained in Great Britain, but in Scotland oil shale forms the basis of a considerable industry. The production of this mineral in 1901 was 2,354,356 tons, of which more than half was obtained in the county of Linlithgow. Similar deposits are mined in France and New South Wales, the amount of kerosene shale obtained in the latter country during 1901 being 54,774 tons.

Ozokerite.—The most important deposit of this mineral wax is at Boryslaw, in Galicia, where it occurs in the fissures of the Miocene shale and sandstones. Petroleum was obtained in the district from shallow wells as early as 1856, but the ozokerite was not worked until 1862 The output from Galicia during 1901 was 2,707 tons, and the present selling price of the product is 84*l*. per ton.

Asphalt.—The term asphalt is usually applied to limestone impregnated with bitumen. Pure bitumen is sometimes met with in veins, as at Bentheim in Hanover, in New Brunswick, and in Barbados, where it is known as manjak. A very pure form is obtained from the Dead Sea, but the most celebrated deposit, which has been worked for the last century, is the Pitch Lake of Trinidad. About 120,000 tons of the pitch are obtained annually in Trinidad, and it is considered that at this rate of extraction the deposit will still last for more than a century.

The mining of asphalt rock for paving purposes has developed very rapidly since its first application in Paris in 1838, and at the present time the total production is about 600,000 tons per annum. The oldest mines are those of Seyssel, near Bellegarde, on the Rhone, and of the Val de Travers in the Swiss Canton of Neuenberg. The Val de Travers deposit consists of a bed of bituminous limestone of cretaceous age, from 12 to 24 ft. in thickness, and it contains 10 per cent. of bitumen. At the present time the most important mines are those of Ragusa, in Sicily, the production of which has increased from 4,000 tons in 1879 to 79,000 tons in 1901. The asphalt from this source consists of Miocene limestone, containing 10 to 18 per cent. of bitumen. In the United States asphalt is mined chiefly in Utah and California, where deposits of considerable extent have been opened up during recent years.

A second group of non-metallic minerals can be made of those which are soluble in water and are conveniently described as "Salts." About twenty of these minerals are of economic importance, and certain of them are mined in enormous quantities. The following are the principal members of this class:—

Salt.—The world's production of rock salt, evaporated salt and sea-salt during 1901 amounted to 12,864,589 metric tons, of which the United States contributed 20·1 per cent., Russia 15·1, the United Kingdom 14·9, Germany 12·1, India 8·7, France 7·0, and Japan 5·1.

The annual consumption (in lb.) of salt as a condiment per head of population in the principal countries of the world varies considerably, and is estimated as follows:—France 11·4, Italy 13·7, Germany 16·0, Austria 17·0, Russia 18·6, the United Kingdom 27·5, and the United States 33·0. In Germany careful statistics are kept of the consumption of salt for agricultural and industrial purposes, and 565,517 tons were thus used in 1901. Of this total 254,433 tons were used in the manufacture of sodium carbonate and sulphate; 102,553 tons in other chemical operations; 21,899 tons in the metal trades; 109,949 tons for cattle food; and 3,441 tons as manure.

England is well supplied with beds of salt and brine springs, the most important deposits being those in Cheshire, where mining has been carried on since 1670, and at the mouth of the Tees, where the beds cover 20 square miles and contain 2,000 million tons of salt. In this country the salt is chiefly obtained from brine, the quantity of rock salt mined being less than one-tenth of the total.

The manufacture of salt from brine is extremely simple, consisting merely in the evaporation of the water and the collection of the salt deposited. The principal modern improvements consist in economising fuel by the utilisation of waste heat, rather than in any essential alteration of the details of the process.

The lecturer gave an interesting account of the important rock-salt mines on the Continent, and also described the methods adopted for the production of salt in tropical countries, where the heat of the sun is utilised to evaporate salt water in shallow pools.

Potash salts.—In certain cases the deposits of rock salt are associated with a number of other minerals, of which the potash salts are the most important. The chief deposits of potash salts occur at Stassfurt in North Germany, and were first utilised in 1850. Their commercial importance at the present time may be gauged by the fact that in 1901 the production amounted to 3,534,895 tons. The deposits of potash salts at Stassfurt rest upon a bed of rock-salt and consist, in ascending order, of poly-

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halite (sulphate of potassium, magnesium and calcium), kieserite (sulphate of magnesium), carnallite (chloride of potassium and magnesium), and kainite (a secondary formation produced by the action of water on kieserite and carnallite). About sixteen different minerals occur in the Stassfurt deposits, but only the carnallite, kainite, kieserite and salt are of commercial value.

Potash salts have also been obtained since 1887 from the Hercynia mine at Vienenburg, in Brunswick.

Nitrates.—Since 1850 an important industry has arisen in the preparation of mineral fertilisers, and considerable quantities of sodium and potassium nitrates are employed for this purpose. Potassium nitrate is formed when animal or vegetable matter decays in contact with rocks that weather easily, and it occurs as an efflorescence upon the soil especially in hot countries. Commercial supplies are chiefly obtained from India, which produced 11,524 tons in 1901.

Very extensive deposits of sodium nitrate occur in Chili chiefly on the Rio Loa near Caracoles and Taltal. The crude nitrate, which is known as *caliche*, is found in beds 6 in. to 12 ft. in thickness beneath a covering of conglomerate, and it is purified by crystallisation. In 1901 the world's consumption of Chili saltpetre was 1,375,400 tons, of which 1,162,400 tons were used in Europe. Of the total the United Kingdom took 34·10 per cent., Germany 29·59, the United States 14·52, and France 9·30.

Phosphates.—Large quantities of the natural phosphates are also utilised for the preparation of chemical manures, and in 1901 the world's production exceeded 2,750,000 metric tons. The chief supplies are obtained from the United States, France, Algeria, Belgium, and Tunis.

In Great Britain calcium phosphate is obtained from beds in the cretaceous rocks in Bedfordshire and Cambridgeshire, but foreign competition has interfered with the industry, and the output during 1901 was only 80 tons.

The production of phosphate in Tunis has shown a remarkable development. The mineral was discovered in 1885 at Gafsa, where it occurs in rocks of lower Eocene age. The principal bed now being worked is 13 ft. thick, and is extremely rich, containing 59 to 61 per cent. of tribasic calcium phosphate. A concession for working the deposits was granted in 1896, and in 1899 the output was 63,209 tons; in 1902 it had risen to 263,493 tons.

In America the chief deposits of natural phosphates occur in Canada, South Carolina and Florida, those of the two latter States being very extensive. In Canada apatite (calcium phosphate) occurs in rocks of Laurentian age in Quebec and

Ontario, but the deposits cannot be mined and shipped at a profit unless they contain 75 to 90 per cent. of the pure mineral.

Other members of this group of "Salts" are the borates and the alums, but these do not demand special notice.

Another important group of non-metallic minerals comprises the stones which are employed for building and other purposes, the most important of which are sandstone, limestone, dolomite, marble, slate, and the clays employed for brickmaking. Their economic importance will be seen from the figures giving the production of certain of them in the United Kingdom. During 1902 the mineral output of the United Kingdom included 5,483,130 tons of sandstone, valued at 1,798,879*l.*; 12,172,851 tons of limestone (other than chalk), valued at 1,382,132*l.*; 517,363 tons of slate, valued at 1,501,789*l.*; and 15,304,136 tons of clay, valued at 1,758,884*l.* In the United States the value of the entire stone production in 1901 was 12,196,000*l.*

Several of these stones are used for a number of industrial purposes other than building. Thus certain forms of limestone are employed for the preparation of lithographic stones, for which purpose the Jurassic limestone of Solenhofen in Bavaria is specially suitable. It is exported to all parts of the world, and the production in 1902 was 9,020 tons, valued at 35,957*l.*

Large quantities of dolomite (magnesian limestone) are employed as a lining for basic steel furnaces, for which purpose it requires to be dead-roasted until all carbon dioxide and water are removed. Magnesite (native magnesium carbonate) is frequently used for the same purpose, and would be exclusively employed if the supply were not limited and the price correspondingly high. The purest form of magnesite occurs in the Salem district of Southern India, about 200 miles from Madras. The mineral found there contains 47·35 per cent. of magnesia, 51·44 per cent. of carbon dioxide, 0·30 per cent. of ferric oxide and alumina, 0·27 per cent. of moisture, 0·30 per cent. of insoluble siliceous matter and no lime. Its specific gravity is 3·056. This Indian magnesite is specially suitable for the preparation of refractory materials for use in furnace construction, as owing to its purity it can be calcined by heating in the electric furnace. Treated in this way it crystallises into a hard, dense mass possessing the highest refractory properties, which has given excellent practical results.

Other important non-metallic minerals are mica, asbestos, kaolin, gypsum, and sulphur, and the first two of these may be specially noticed.

Mica.—Mica is widely distributed as a constituent of granite and other rocks, and has received a large number of important industrial applications. Its earliest use was probably for window-panes, under the name of "Muscovy glass," and it

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is now extensively employed as a transparent medium which is not affected by sudden exposure to heat. Large quantities are also used for insulating purposes in dynamo construction, and the scrap mica is utilised as a lubricant, as non-conducting packing material, and in paper manufacture. Transparent mica measuring eight inches square fetches 18*s.* per lb., whereas the scrap is sold at 13*s.* per cwt.

India supplies the largest amount of mica at the present time, the other chief contributors being the United States (North Carolina and New Hampshire), Canada (Quebec), and Brazil. Smaller quantities are also obtained from Norway, Siberia and China.

The mica industry is of considerable importance in India, where in 1900 there were 131 mines, employing 9,517 persons, at work. The output amounted to 916 tons, valued at 885,669 rupees, and of this total more than half was produced in the Nellore district of Madras. In 1901 the total output was 1,138 tons, valued at 995,892 rupees. The system of mica-mining in operation in India is in many cases of a very primitive type and might be greatly improved.

During 1901 the United States produced 360,060 lb. of sheet mica valued at 19,762*l.*, and 2,171 tons of scrap mica valued at 3,944*l.* The value of the Canadian output was 32,827*l.* In the United Kingdom mica is obtained in Cornwall as a by-product in the preparation of china-clay, the amount yielded in 1901 being 3,216 tons, valued at 1,266*l.*

Asbestos.—Asbestos occurs in commerce in two distinct forms; one of these is an anhydrous silicate, known as amianthus, and consists of brittle fibrous hornblende, which is unaffected by acids, whereas the other form, known as chrysotile, or serpentine asbestos, is a hydrated compound which is attacked by acids, but is characterised by great elasticity of its fibres. The first form occurs principally in Italy and Austria, whilst the latter is found chiefly in Canada in the province of Quebec. Both minerals can be readily divided into fine fibres, which can be spun like cotton.

Canada produces the greater proportion of the world's supply of asbestos, the output for 1901 being 34,545 metric tons. The next country in order of production is Russia, with an output of 3,845 tons. In Canada asbestos is mostly obtained by quarrying, and the better varieties are picked out by hand. The first class has fibres of over 1¼ in. in length, while in the second class the length varies from ¼ to 1¼ in. The poorer qualities, known as "fibre" and "paper stock," are produced by mechanical dressing. The Danville Company pulverises the waste asbestos, and, after the addition of a quantity of serpentine, the product is known as "asbestic"—a material which is now largely used for fire-proof buildings.

World's [illegible] the [illegible]rals.

The production and value of the different qualities of asbestos mined in Canada during 1901 was as lollows:—

First crude ...	2,083	tons,	valued at	180-200	dols. per ton,
Second crude...	2,660	„	„	100-128	„ „
Fibre	14,659	„	„	30-60	„ „
Paper stock ...	14,054	„	„	20-28	„ „
Asbestic ...	6,831	„	„	2-4	„ „

According to Mr. F. Cirkel, 100 tons of mineral mined, yield 1½ tons of crude and 5 to 8 tons of fibre and paper-stock.

The concluding lecture of the series was devoted to a consideration of the precious and ornamental stones and the rare earths. The modes of occurrence, the present sources of supply and the methods employed in the mining of all the important gems were fully described, but for these the original should be consulted.

A brief notice may be devoted to the rare earths, some of which have attained considerable industrial importance since the introduction of the system of incandescent gas lighting. The principal constituent of the mantles is thoria, and the chief source of this oxide is monazite, a mineral which occurs in Brazil, Norway, the Urals, Carolina and Canada. Monazite is found in crystals, which are sometimes of considerable size, and in irregular masses, but the deposits which are of commercial value are the sands formed by the disintegration of rocks which originally contained monazite. The principal deposits of this kind occur in the United States and in Brazil. In the former country the workable deposits of monazite sands are confined to Carolina and cover an area of 1,600 to 2,000 square miles. Their thickness varies from one to two feet and the monazite present ranges from an infinitesimal proportion to one or two per cent. In Brazil the deposits occur as beach sands which have been concentrated by the action of the waves.

The sand is cleaned and concentrated by washing with water, and if magnetite be present it is removed by a magnetic separator. A cleaned sand containing 65 to 70 per cent. of monazite is considered to be of good quality, but in South Carolina a richer product, containing 85 per cent., is obtained.

The production of monazite is very irregular, and at the present time the market easily absorbs the whole of the output.

The highest price recorded was in 1887 when it reached 1*s*. per lb., but at present the price varies from 2*d*. to 4*d*. per lb. for a proportion of thoria varying from 2 to 6 per cent. The production in the United States during 1901 was 748,736 lb., valued at 11,852*l*., and in Brazil it was 1,643 tons, valued at 23,937*l*.

THE BLAIRMORE FRANK COALFIELDS OF BRITISH COLUMBIA.

The Blairmore Frank coalfields are situated a few miles east of the summit of Crow's Nest Pass, British Columbia, and are separated from the Crow's Nest coalfield by the main range of the Rocky Mountains. The rocks of the region are Devono-carboniferous and middle, lower and upper Cretaceous. The two latter formations are economically of most importance as they contain the principal coal-seams. The Devono-Carboniferous rocks consist principally of limestones with some beds of quartzite near the top. The principal beds in the lower Cretaceous formation in ascending order are as follows:—(1) gray and black shales (700 ft. thick); (2) productive coal-measures (740 ft. thick); (3) hard cherty-conglomerates (30 ft. thick); (4) light-coloured sandy shales and shaley sandstones (1,850 ft. thick); and (5) volcanic ash rock and agglomerates (maximum thickness 1,500 ft.).

There is a general similarity between this structure and that of the Crow's Nest coalfield, with, however, a marked diminution in the thickness of the rocks. This is particularly noticeable in the case of the dark shales underlying the coal-seams which represent the Fernie shales of the Crow's Nest coalfield.

A section of the coal measures at Cat Mountain showed 16 seams of coal, the thickest being 15 ft. 3 in. Another section at Byron Creek, which was probably incomplete, showed 10 seams of coal with a total thickness of 102 ft. A partial section at McGillivray Creek showed 5 seams with a total thickness of 50 ft.

The coal itself is generally of good quality and resembles in appearance that from the Crow's Nest field. Analyses of samples from the Gold Creek Collieries gave ashes varying from 7·6 per cent. to 8·5 per cent., volatile matter 23 to 24 per cent. with moisture less than 1 per cent.

The most highly developed property in this district is a mine near Frank, on the east side of Turtle Mountain. The seam worked here is the upper one of the series and varies from 9 to 12 ft. in thickness. The output from this mine is 500 tons per day.

THE MURCHISON GOLDFIELD, WEST AUSTRALIA.

The Murchison Goldfield as originally constituted was first proclaimed in 1891, and embraces the districts of Lennonville, Mount Magnet, and Boogardie. The auriferous deposits, according to a recent report of the Geological Survey of Western Australia, are of two types, white quartz reefs and laminated quartz and jasper veins; the whole being enclosed in a belt of altered rocks containing diorite, diabase pyroxenite and schists, provisionally termed greenstone.

These greenstones are traversed by belts of laminated quartzites much faulted, and it is along these lines that the rich "chutes" of gold occur. The formation varies between 15 miles in width at a point South of Mount Magnet, and 5 miles between Mount Magnet and Lennonville. The banded quartzites are of two varieties, "the hæmatite bearing" or Boogardie type and "the non-hæmatite bearing" or Lennonville type, of which the former is the more prevalent.

While outcropping in low, rough ridges of compact quartz the Lennonville quartzites are found, beneath the surface, to change to alternating thin bands of hard white quartz and soft kaolin, invariably containing gold. The "Boogardie" type differs from the preceding in being more compact and in being highly impregnated with hæmatite and occasionally magnetite.

The manner in which the gold occurs in these two types of quartzites differs considerably. In the Lennonville district the gold is obtained in the main body of the quartzite itself, generally occurring in "chutes," some of which are of considerable extent. In the Boogardie district, on the other hand, the quartzite carries but a slight trace of gold, and it is only at one or two places at the northern end that it is rich enough to pay for working. The bulk of the gold is obtained in "chutes," occurring in the faults crossing the quartzite bars.

The principal mines of the Mont Magnet district are seven in number, those of the Boogardie 12, and Lennonville 13. The total of worked ore up to 1902 was 191,820 tons, which yielded 191,518 ounces of gold, an average of 0·99 ounces per ton.

THE ALBERT SHALE DEPOSITS OF NEW BRUNSWICK.

The Albert Shale deposits of Albert and Westmoreland counties, New Brunswick, to which attention has already been directed in the "Imperial Institute Bulletin," vol. i., 1903, p. 183, were known and worked for oil before the present Canadian oil-fields were discovered.

The advent of cheap oil made the industry unprofitable, and the mines were closed, but with the high prices prevailing for oil in Canada it is considered that these shales may be worked at a profit, and it is possible that operations may be resumed in the near future. The general account of these deposits, given in the Annual Report of the Geological Survey of Canada for 1902, is therefore opportune. It contains a *resumé* of what is known about these deposits, and shows that these shales extend across the two counties mentioned as a comparatively narrow band in an east to west direction for a distance of over thirty miles. The band is not, however, continuously exposed, being sometimes covered over by overlying sediments of either lower Carboniferous or Millstone-grit age. In Albert county the deposits extend from the northern flank of the Caledonian range of mountains across the Petitcodiac and Memramcook Rivers and along the roads between Dorchester and Memramcook. The best exposures are seen at the Albert mines, four miles west of the Petitcodiac River, but good exposures also occur at Baltimore, six to eight miles from these mines. The exposed width of the shales seldom exceeds half-a-mile, and the thickness of the whole formation has been estimated at 1,000 ft. The oil shale bands occur in different parts of the oil shale body, and consist of thick seams of a dense, black, massive rock.

At the Albert mines there are at least five beds ranging in thickness from three to six feet. The yield of oil from this material is reported to be sixty to sixty-five gallons per ton, as against the thirty to thirty-five gallons obtained from Scotch shales.

At Baltimore there are four or five beds of oil shale varying from three to six feet in thickness. At Turtle Creek two bands are said to have a thickness of about twenty to twenty-one feet respectively, and to yield eighty to eighty-five gallons of oil per ton.

The total quantity of oil-shale in these deposits is estimated at 270,000,000 tons.

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THE OIL-FIELDS OF THE GASPÉ PENINSULA, LABRADOR.

The existence of petroleum deposits in the Gaspé Peninsula has long been known from the presence of oil springs at Tar Point, St. John's River and other localities. The rocks in which the oil occurs are of Devonian age, and the statement has been made repeatedly that this area is geologically similar to the oil-fields of Pennsylvania, and that the conditions for oil production in the two localities are practically the same. The report of the Geological Survey for Canada for 1903 shows, however, that the Gaspé area differs in several important respects. In the first place there does not appear to be true oil-bearing strata underlying the area, though oil occurs in small quantity in some portions of the sediments. In the second place the tilted and faulted character of the rocks throughout the greater part of the Devonian basin both of Eastern Gaspé and along such rivers as the Bonaventure and the two Cascapedias to the west are unfavourable to the occurrence of oil in large quantity Thirdly, the anticlines, instead of being in gently inclined strata, are usually sharply defined, the inclinations of the opposing sides being steep and complicated by faults.

The early boring operations which were undertaken in this district some 40 years ago were without practical result; more recently, however, in 1891, the work of exploration was recommenced, and about 1,000,000 dollars have been since expended in preliminary boring operations In all fifty-two boreholes have been put down, thirty-nine of which were made by the Petroleum Oil Trust, of London, and twelve by the Canadian Petroleum Company, of Manchester The total amount of oil obtained from these borings in 1901 and 1902 amounted to 10,611, or about 235 barrels.

Dr. Ells, of the Canadian Geological Survey, who examined the district, concludes from a careful consideration of all the data at present available that the outlook for this field as a producing centre cannot be regarded as favourable. The absence of well-defined oil sands and the abundance of salt water which has been encountered in most of the borings already made are all against its successful exploitation. At present the location of boreholes is a matter of chance, and borings have been made to a depth of over 3,500 feet, at enormous expenditure and in every case without any satisfactory results. These extensive investigations appear to negative the possibility of discoveries of large deposits of oil in the district.

THE NATURE AND COMMERCIAL USES OF BEN OIL.

Oil of "Ben" or "Behen" is a fixed oil expressed from the seeds of *Moringa pterygosperma* and *Moringa aptera*. These trees belong to the Natural Order *Leguminosæ*, are indigenous to India, Arabia and Syria, and were introduced into Jamaica from the East Indies in the year 1784. The oil is inodorous, clear, and nearly colourless, and is capable of remaining for a long time without becoming rancid. It is said to contain the glycerides of margaric, oleic and behenic acids. At one period it constituted a valuable article of commerce with the East until excessive imposts and extensive adulteration brought it into disrepute.

In Jamaica attention was drawn to the valuable properties of the oil as early as the year 1817, when a petition containing the following particulars was presented to the House of Assembly. It was pointed out that the "Morengo" plant grows equally well on poor or rich soil, and is but little affected by drought. Six trees of the age of three years, grown in barren soil, each yielded 3 lb. of seed; the seed yielded 2 oz. of oil per lb., and thus 36 oz. of oil was obtained from the six trees. The oil was said to be useful for salads and culinary purposes and to be equal to the best Florence oil as an illuminant, giving a clear light without smoke. It does not become rancid or acquire any disagreeable odour, and it yields a good soap. The seeds should be sown six inches apart, and the young trees transplanted within a year. The trees should be thinned in the third or fourth year, and, if topped at the proper season, will each produce about 10 lb. of seed per annum. If the trees are planted four feet apart in rows 66 ft. long and 8 ft. wide, there will be 1,320 trees per acre. Each tree will yield 6 oz. of oil which, at 90 oz. to a gallon, is 88 gallons per acre. With the oil at 13*s*. 4*d*. per gallon, 100 acres would produce 5,866*l*.; allowing 2,000*l*. for contingencies, there would remain 3,866*l*. net profit. It was stated that the leaves and young branches are useful for feeding cattle in dry weather, and that the residue left after expressing the oil can be used as a food for pigs and poultry.

In 1854 a paper on this subject was read by Mr. H. J. Kemble before the Jamaica Society of Arts. By expression with very imperfect machinery he obtained 1½ oz. of oil from 1 lb. of seed. The oil was submitted to two watch-making establishments in Kingston, and it was reported to be equal to the "watch oil" imported at a cost of 2*s*. 6*d*. for a bottle of the size of a man's little finger. Although the demand for this oil for lubricating purposes might not be sufficiently great to be remunerative, the author was of opinion that it could be produced and sold at a price which would enable it to compete with other oils used for domestic purposes, since the cultivation is attended with but little difficulty and expense. This he illustrated with the following estimate:—

Number of trees per acre	1,820
Yield of seed per acre at 3 lb. per tree ...	3,960 lb.
Yield of oil per acre at 2 oz. of oil per lb. of seed	7,920 oz.
(at 160 oz. per gallon)	49½ galls.
Value of oil per acre at 8*s*. per gallon	19*l*. 16*s*.
or from 100 acres	1,980*l*.

In an account of Ben oil given by Mr. William Hamilton, M.B., in the "Pharmaceutical Journal," vol. v., p. 8, it is said that Geoffry obtained 30½ oz. of oil from 8 lb. of decorticated seed, or about 24 lb. per 100 lb. of seed. The oil is particularly valuable for ointments since it can be kept for almost any length of time without undergoing oxidation. This property, together with the absence of colour, smell and taste, renders it peculiarly adapted for use in the "enfleurage" process of extracting perfumes.

A firm of oil manufacturers in Kingston, Jamaica, have recently made an experiment to ascertain the cost of production of the oil. They paid 8*s*. per cwt. for the seed, and found that the husks constituted 40 per cent. and the decorticated seeds 60 per cent. The seed, when expressed warm, but not hot, yielded about 12½ lb. of oil per cwt. Their final result showed a cost of 80*l*. per ton for the oil. A sample of this oil was sent to England for valuation, and a report was received which stated that "Oil of Ben" was now superseded by an oil obtained from the head of the sperm whale, and that the value of the sample submitted was about equal to that of the best cotton seed oil.

In May, 1903, a small specimen of Ben oil was supplied to Dr. J. Lewkowitsch from the Imperial Institute. A report on this sample has been published in "The Analyst, 1903," vol. 28, p. 343, from which the following extract is taken:—"The chief interest in this oil depends on its low iodine value; this explains why the oil is specially applicable for lubricating watch-springs and other delicate machinery." The following constants were determined:—

Specific gravity at 15° C. (water at 15° C. = 1) ...	0·91267
Iodine value	72·2
Iodine value of the liquid fatty acids	97·53
Refraction (butyro-refractometer)	50·0°

A sample of pods and seeds which were identified as those of *Moringa pterygosperma* has been received recently at the Imperial Institute from Northern Nigeria. On examination in the Scientific and Technical Department, the seeds were

Natural and Commercial Uses of Ben Oil.

found to contain 38 per cent. of a pale yellow oil which was almost odourless, and possessed a bland agreeable taste. This oil (obtained by extraction with ether) consisted of a liquid and a solid portion, which were separated by filtration at 17 to 18° C. and separately examined.

The analytical constants of these two portions are given in the following table:—

	Liquid portion	*Solid portion*
Specific gravity at 15° C.	0 914	—
Acid value	15·3	—
Free fatty acids (calculated as oleic acid)	7·7 %	—
Saponification value	189·2	194·4
Ether value	173 9	—
Iodine value	70·7	68·3

Samples of the seed and of the oil were submitted to brokers for valuation. They reported that in order to obtain trustworthy commercial quotations, large samples of the oil would be necessary for practical trials, and that if the results of these trials proved satisfactory the oil would probably be able to compete for edible and culinary purposes with American refined cotton seed oil, which is at present worth about 22*l*. per ton. The seeds were valued at about 7*l*. per ton delivered in London.

Another sample of Ben oil from Jamaica was received at the Imperial Institute in December, 1903. It had a very slight, pleasant odour, and an agreeable taste On examination in the Scientific and Technical Department it yielded the following results. When filtered at 17° C. it was found that 60 per cent. of the material was liquid, whilst the remaining 40 per cent. consisted of a nearly white, solid fat. The liquid portion was clear, bright, and of a pale yellow colour. The constants of these two portions were found to be as follows:—

	Liquid portion.	Solid portion.
Specific gravity	0·9124 at 15° C.	0·8650 at 100° C.*
Acid value	8·7	7·2
Free fatty acids (calculated as oleic acid)	4·4 per cent.	3·6 per cent
Saponification value	196·3	198·6
Ether value	187·6	186·4
Iodine value	70·1	65·2

* Compared with water at 15° C.

From these accounts of Ben oil, it appears that although it would not yield the extravagant profits expected in 1817, yet if it could be produced at a sufficiently cheap rate it would be likely to find a market for dietetic purposes, and possibly an opening might be secured for the liquid portion of it as a lubricant for fine machinery.

The cost of producing the oil as given by the firm of oil manufacturers at Kingston, Jamaica, appears very large; it must be pointed out, however, that the initial cost of the seed was very considerable, the yield of oil was less than would be expected from the fact that the decorticated seed contains from 35 to 38 per cent. of oil, and no allowance seems to have been made for the residual cake which might be of value as a cattle food.

COTTON CULTIVATION IN THE SUDAN.

The extension of cotton cultivation in the Sudan is alluded to by Lord Cromer in the "Report on the Finances, Administration and Condition of Egypt and the Sudan in 1903." It is pointed out that at the present time the greater part of the cotton is grown on lands watered only by rain, whereas it is highly desirable that the plant should be cultivated on irrigated lands. It is not considered necessary to delay the progress of the industry in the Sudan until large irrigation works, capable of increasing the water supply both of this country and Egypt, are completed, but it has been decided to allow sufficient water to be taken from the Nile in summer to permit of an experiment on a fairly large scale being made in the Berber district Further, the hope is expressed that it may be possible to irrigate some parts of the Sudan without having recourse to the waters of the Nile.

An enquiry has been made recently with regard to the possibility of developing the cultivation of cotton in the Tokar Plain, near Suakin, by means of improvements in irrigation, but it has been found that it would not be worth while to go to any great expense in this matter, since the supply of water is insignificant in amount and extremely irregular.

It is stated that cotton could no doubt be grown in the Bahr-el-Ghazal Province on non-irrigated land, but it is feared that, even when the Suakin-Berber railway is completed, the cost of transport from this remote region will be almost prohibitive.

The cultivation of cotton on the Blue Nile and Dinder rivers has been dealt with in a recent report of the Moudir of Senaar.

Cotton is grown on the Blue Nile both on irrigated and non-irrigated land, but on the Dinder it is cultivated entirely without irrigation. The varieties grown are "Abu Hareira," "Belwa," and "Mumtez." The two former plants are indigenous, and are grown chiefly on the river banks; they last for three years or more, and yield the best cotton in the third year. The "Mumtez" variety was probably introduced into the Sudan by Mumtez Pasha during the rule of the former government; it is usually grown on non-irrigated land and is renewed every year.

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The cotton plants receive no attention during the winter, but the ground is roughly cleared at the beginning of the rainy season. On non-irrigated land the seed is sown in July, and, in all cases, the cotton is ready to be gathered after the lapse of four months. The collection of the fibre is generally effected in three operations; the last pickings are inferior in quality to the two earlier crops since at this time the plants are adversely affected by the drought.

The best districts for cotton growing or non-irrigated land on the Blue Nile extend from Singa southwards as far as Abu Naama. The average crop in a good year amounts to about 400 rottles per feddan (or 360 lb. per acre), including the seed, whilst in a bad year it falls almost to nothing.

During the year 1903 an experiment was commenced at Wad Medani with seed of the "Mitafifi" variety, which was distributed to the natives. The assistance of an Egyptian cotton expert was obtained, and the leading sheikhs were brought together and given practical instruction in cultivating cotton by irrigation. The natives cling to their old method of growing the plant on non-irrigated land, as it gives but little trouble and yields all the fibre required for their own use.

On the Dinder, each village was directed to sow cotton seeds at the end of July on a small patch of land irrigated by "shadoofs." In September the results were found to be most satisfactory, both the "Mitafifi" and "Mumtez" varieties having grown well.

The supply of labour in the Sudan is somewhat precarious. Owing to the great decrease of population which has recently occurred an external supply of labour will probably be needed.

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COTTON CULTIVATION IN THE FRENCH COLONIES.

The subject of the insufficiency of the cotton supply is receiving attention not only in this country but in all parts of the world in which the cotton manufacturing industry is established.

In France, strenuous efforts are being made by the Colonial Cotton Association to advance the cultivation of cotton in the French Colonies. The objects which this Association have in view are: (1) to develop the cultivation of cotton in those Colonies in which the plant already grows; (2) to study methods of ginning and baling adapted to the nature of the cotton and the local resources; (3) to give consideration to the means of transport and, acting in conjunction with the public authorities, to increase these and make them as economical as possible; (4) to induce growers to improve the quality of their products by purchasing the best varieties of seed and thus to facilitate the creation of markets, and (5) to distribute selected native or foreign seed in the villages in order to obtain more highly esteemed varieties of cotton.

A report of the progress of the Colonial Cotton Association in pursuit of these objects during the first year of its existence was given recently at the Annual General Meeting of the Association, and has been published in the "Revue des Cultures Coloniales," 1904, vol. 14, pp. 129-144.

Whilst the experiments in cotton growing, which are described below, were in progress in the Colonies, ginning machines of various systems, designed for manual labour, were purchased in England and America and tested in Havre. As a result of these trials, a number of gins were purchased and sent to different Colonies. During the year 1903, the Colonial Cotton Association distributed 3,025 kilos of seed and bought 30 ginning machines costing about 750 francs each.

ASIA.

Some years ago experiments in cotton growing were made in Tonkin and in Thanh-Hoa, the northern province of Annam. American, Indian and Egyptian seed was distributed to the colonists and to the chiefs of military districts, whilst a further quantity was sown at considerable expense in particular concessions The results were unsatisfactory and the products showed evidence of degeneration; the fibre was short, harsh and unworkable Much difficulty was experienced in carrying on the cultivation, and the crops suffered owing to the irregularity of the rainfall.

At the present time an attempt is being made at Dam-Xuyen, near Hanoi, to grow arborescent cottons derived from seed imported from India; these plants, after several seasons, have

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attained an almost wild state without undergoing alteration or degeneration.

Cotton is cultivated on a small scale in all parts of Annam. The fibre is strong, fairly long and regular, and of good colour, but somewhat woolly; it is comparable with Indian cottons of good quality. The small quantity produced in this country, however, is in the hands of the Chinese, who make advances on the crops and re-sell the cotton at a high price.

In Cambodia, a cotton plant which yields a fibre of regular, silky staple is grown along the course of the River Mekong, but here again the trade is in the hands of the Chinese, and nearly the whole of the product goes to Japan.

The cultivation of cotton in Indo-China could probably be extended, but the crops would either be used locally or exported to China or Japan; for this reason the French Colonial Cotton Association has not attempted hitherto to develop the industry in these French Colonies.

OCEANIA.

Cotton occurs in several French Colonies of Oceania. In New Caledonia, where the plant is known to grow wild, experiments were made in 1869-1871 with "Sea Island" seed, but the results were unsatisfactory; the soil is poor, the seasons are irregular, and the climate is too moist and cold at the period in which the capsules ripen.

In the Loyalty Islands, which lie to the east of New Caledonia, the climate is drier and more equable, and the seasons are more regular. The Vice-President of the Chamber of Agriculture of New Caledonia has proposed recently to endeavour to introduce cotton growing among the natives, and consignments of "Abassi," "Mitafifi," and "Sea Island" seed have been despatched for this purpose.

The cultivation of cotton was at one time carried on in Tahiti to a considerable extent; the fibre produced was long, silky and resistant. The following table shows the quantities exported in three typical years:—

Year.	Exported to France.	Exported to Other Countries.
	Kilogram.	Kilogram.
1880	137,567	481,904
1890	22,799	196,986
1902	10,939	6,198

The only cotton now produced in the island grows wild, as the natives do not find its cultivation sufficiently remunerative.

A small quantity of cotton is also grown in the Marquesas, and the whole is exported.

AFRICA.

ALGERIA.—The lack of irrigation, the high rent charged for the land, the scarcity of labour, and the unfavourable climatic conditions render it improbable that cotton growing in Algeria will develop to any considerable extent. During the American Civil War, however, cotton was cultivated in this Colony on an extensive scale, the industry being aided by large Government bounties. When the bounties were withdrawn, the cultivation rapidly declined; the plants degenerated, the seed required frequent renewal, and the growth of weeds necessitated so large an amount of labour, that the industry was no longer remunerative. A few years ago some experiments were made at Fougala, in l'Oued Rir and at Biskra; samples produced at the last-mentioned locality, where 4,000 hectares are devoted to cotton, were of fine quality and long staple.

TUNIS.—The meteorological conditions in Tunis are not favourable to cotton cultivation. The plant would no doubt grow well on irrigated lands, but such areas are limited in extent and very costly. Cotton occurs in the oases, but the natives do not devote themselves to its cultivation, as they do not consider it sufficiently profitable, and prefer to use the available water for watering their vegetables, cereals and fruit trees. Experiments are being carried on at the present time in Créteville, where samples of Mississipi and Texas seed have been forwarded for the purpose.

SOMALI COAST.—An attempt is being made to grow cotton at Jibuti from "Sea Island" and "Mitafifi" seed, but even if the experiment succeeds it does not appear possible to develop the industry since the natives have no idea of agriculture and no taste for it.

LA REUNION.—At the time of the American Civil War the wealth of La Réunion was greatly enhanced by its cotton trade, but the industry was afterwards abandoned. In the year 1890 the Chamber of Commerce of Havre sent an expert to the country to study the possibility of reviving the cultivation. His experiments led to the conclusion that cotton grows well in the island, but that the industry cannot be made profitable owing to the scarcity of labour; he also remarked that cyclones are frequent, and that the bolls are particularly liable to attack by insects.

The cultivation of the sugar-cane in La Réunion is gradually declining, and for this reason it is desired to re-establish cotton growing; a consignment of seed was forwarded to the island in 1903 and is at present in course of trial.

MAYOTTA.—The sugar industry has failed also in Mayotta, and its replacement by cotton cultivation is regarded as worthy

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of consideration. A sample of cotton grown in the year 1890 was reported to be of excellent quality and remarkably long staple.

COMORO ISLANDS.—Interesting specimens of cotton grown in Great Comoro have been submitted to the Colonial Cotton Association.

MADAGASCAR.—Before the introduction of European cotton materials into Madagascar, cotton was cultivated by the natives, particularly in Emyrne and in the Betsiléo. The indigenous cotton is not of very good quality; labour is abundant in Emyrne, but the soil is poor and the cost of transport from the interior of the island is considerable. The only region in which the cultivation could be developed extensively is the western side of the island, where the climatic conditions seem perfectly suited to the cotton plant, and where the watercourses are, for the most part, navigable.

The seed is sown from November to January before the heavy rains, and the harvest is gathered from April to June after the later rains which occur at the end of March.

In 1903 some experiments were undertaken on the cultivation of cotton from Egyptian seed, but, unfortunately, most of the plants were destroyed by a cyclone, only those escaping which were derived from the seed of plants already acclimatised. Some samples of the "lint" produced showed deterioration, were harsh to the touch and of fine but irregular staple, whilst specimens of "Grifton" and "Sea Island" cotton which originated from seed derived from previous trials were long and silky. These trials are being continued during the present year with seed of the "Sea Island," "Abassi," "Mitafifi," and "Jannovitch" seed.

A sample of cotton grown near Ambositra from Egyptian seed was reported to be of good colour, but of irregular, soft and woolly staple; and another sample, from Georgia seed, was stated to be of good colour and quality, and of fine and very long staple.

An experiment station is to be established in the West of Madagascar for the cultivation and acclimatisation of various cotton plants. The Governor and the local Chamber of Agriculture are taking great interest in cotton growing, and 400 kilos. of Egyptian and American seed and a saw-gin have been forwarded to the island by the Colonial Cotton Association.

CONGO.—The prospects of cotton cultivation in the French Congo are not promising; the cotton is short, labour is expensive, and the climate does not appear to be favourable.

DAHOMEY.—In Dahomey, beyond the forest of oil palms which extends 120 kilometres from the coast, is found an argil-

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laceous and ferruginous soil which seems suitable for the cotton plant. In these elevated regions cotton has always been grown by the natives for their own use, but the cultivation has gradually diminished owing to the increasing quantity of manufactured cotton goods imported from Europe.

The development of the industry will become possible as soon as the railway will permit the transport of the raw product at a reasonable cost, since there is an abundance of efficient labour available. The seasons are well marked, and the country is traversed by four large rivers which overflow their banks irregularly from May to September. The inhabitants are said to be disposed to plant cotton extensively. A supply of Mississipi and Texas seed has been forwarded to several persons in the Colony, and a ginning machine has been sent to Kotonou and placed at the disposal of the Governor.

In April, 1903, 2,000 kilos. of cotton were exported from Savalou to Havre. This product was obtained from plants of one year's growth, the plantations being renewed annually by the natives. The staple was of a yellowish colour, irregular, 18-25 mm. in length, harsh to the touch, and lacking in lustre and silkiness. On submitting the material to spinning and weaving trials good results were obtained.

IVORY COAST.—Cotton grows wild in the north of this Colony, whilst in other parts it is cultivated by the natives. The seed is sown in April and May and the harvest is gathered in December and January. Primitive methods of cultivation are employed, and the product is of short and irregular staple.

FRENCH GUINEA.—Cotton growing cannot be attempted in the coast regions of French Guinea on account of the persistent rains. In Rio-Pongo, however, on the banks of the River La Fatallah well defined dry and wet seasons occur, and it is possible that satisfactory results might be obtained in this district. Wild cotton plants are met with at a distance of about 300 kilometres from the coast, and, owing to the possibility of irrigation their cultivation would be easy.

During 1900-1901 an attempt was made to grow cotton in High Guinea; no less than 30 different kinds were planted, but with the exception of two Egyptian varieties ("Abassi" and "Mitafifi") none of them succeeded nearly as well as the indigenous cotton. In March, 1903, another experiment was commenced under the auspices of the Colonial Cotton Association. American, Egyptian, Peruvian and Haytian seed was sown, and millet was planted between the different varieties in order to prevent hybridisation as far as possible. The results showed that "Mitafifi" was the only variety which grew well and did not appear to be injured either by the great heat or by the protracted rains of the winter season. These experiments

Cotton Cultivation in the French Colonies.

indicated, therefore, that only the Egyptian varieties are capable of becoming acclimatised to this region.

The districts of Saloum and Casamance seem to offer very favourable conditions for cotton cultivation. Several experiments have been made in the latter locality and two varieties in particular have succeeded well, viz., long-stapled Georgia cotton and short-stapled Louisiana cotton. The latter variety resembled the indigenous cotton of these regions, but had a very fine staple of about three times the length.

SENEGAL.—There are vast territories in the hinterland and on the river banks of this Colony available for cotton growing, but, owing to the insufficiency of the rainfall, cultivation can only be carried on where irrigation is possible. An experiment has been made recently on lands situated at the junction of the rivers Taouey and Senegal, where the fields can be irrigated during the whole of the vegetative period of the cotton plant. Seed of several varieties, American, Egyptian and Peruvian, was sown at the beginning of August, 1903. The crops obtained were of good quality, and neither the American nor the Egyptian varieties appeared to have degenerated. Another trial, carried out at Podor, confirmed the conclusion that cotton of a useful quality can be grown successfully in Senegal, but only on irrigated land.

In 1903, an experiment with American, Egyptian and indigenous seed was made in High Senegal. The cultivation was carried on exactly in the manner practised by the natives and without irrigation. From the results obtained it is evident that Egyptian cotton cannot be grown successfully in High Senegal, but that the American variety "Excelsior" seems capable of propagation.

The cultivation of cotton is being encouraged at St. Louis, and the Colonial Cotton Association has forwarded an American ginning machine to this town and placed it at the disposal of the local Chamber of Commerce.

FRENCH SUDAN.—In the French Sudan the river Niger is known by the names of the Joliba and the Issa-Ber; the former extends from its source in High Guinea to the lake district of Jenne, and the latter commences at this point and ends at Say. The climate of the Joliba region is divided into sharply defined periods. The rainy season begins from May 15th to June 1st and terminates between the 15th and 20th of October. The dry season commences in November, and intense heat is experienced from the middle of March until the end of April. The climate of the Issa-Ber district is more healthy; it is drier and warmer, and the wet period is shorter and less dangerous. The rainy season extends from the end of June

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to the beginning of October. The dry season commences with thick fogs in October, and the greatest heat occurs in May, June and July.

The rivers overflow their banks in the rainy season and, in consequence, the lands maintain during the winter a constant and uniform degree of moisture extremely favourable to the cultivation of cotton.

Cotton growing has long been practised by the natives. The population is densest on the banks of the river in proximity to the areas of cultivation. If the native is assured that his crops will prove remunerative he will develop the industry and improve his methods. The supply of labour available is sufficient to put under cultivation the greater part of the lands enriched by the overflow of the Niger. It is evident, therefore, that the French Sudan appears to offer all the conditions required for promptly yielding practical and important results.

In March, 1903, a large supply of American, Egyptian, Indian and Peruvian seed was sent to the Sudan and distributed in the districts of Bammako, Segu and Sansanding on the Niger, and San and Jenne on the Bani. In order to avoid confusion and admixture of the seed, each village was supplied with one particular kind. The natives were instructed in methods of sowing and cultivating by agents of the Colonial Cotton Association. The reports already issued have shown that, on the whole, these experiments have proved extremely successful.

A consignment of indigenous cotton grown in Segu was forwarded to France in 1903. The staple was white, short and somewhat rough, but proved well adapted to the operations of spinning and weaving An experiment with Indian, Haytian and American seed was carried out in the same district. The American varieties yielded a fibre which was greatly superior to the indigenous cotton; its staple was fine, strong, of good colour, and 28—30 mm. in length

During the present year the work of the French Colonial Cotton Association is to be continued in the same manner as that hitherto adopted; the experimental areas, however, are to be of greater extent and less widely dispersed.

SUGAR-CANE EXPERIMENTS IN THE LEEWARD ISLANDS.

The origin of experiments with sugar canes in the West Indies can be traced to the ravages which were caused by the moth-borer and the rind-fungus about the year 1892. At this time the Bourbon cane was generally grown, but as it became evident that this variety was especially liable to disease, experiments were instituted in order to obtain a stronger, and, if possible, to evolve a disease-proof variety. Under the stimulation of the Imperial Department of Agriculture, which was created in 1899 under the direction of Sir Daniel Morris, fresh impetus was given to the movement for the improvement of sugar canes, and experiments were pushed on in several of the West Indian Islands. Amongst others, an extensive series of experiments was instituted, under the superintendence of the Hon. Francis Watts, in Antigua and St. Kitts—two of the islands included in the Leeward group. These have been continued year by year since 1899, and have been gradually extended, so that the results obtained in the season 1902–3 have furnished ample material for the report recently issued.

There were two principal objects in starting these experiments; the one already mentioned was concerned with the improvement of the cane by selection, either vegetative selection, or selection of new seedlings, and the other was the experimental determination of the value of different manures. Each of these necessitated a large number of experimental plots, and an important feature in the cultivation has been that all the canes have been grown in the same way and under the same conditions as the ordinary crops on the estates.

Taking first the experiments with selected varieties, these are divided into two series, according as they were carried out with plant canes or ratoons, and also the average results are tabulated separately for Antigua and St. Kitts. In Antigua, during the season 1902–3, experiments were conducted with plant canes on seven stations, on which the soil varied from a heavy clay to a friable limestone. On one station as many as 35 selected varieties were laid out in plots, but on the remaining six stations 23 selected varieties were grown, and each trial was made in duplicate. The most important criteria in cane cultivation are the tonnage of cane produced per acre, the percentage of juice obtained in the mill, and the degree of purity of the juice, *i.e.*, the relative proportion of sucrose, or true cane sugar, to reducing glucose. From the tabular statement (No. 8) given in the original, which shows the mean values from 11 to 14 plots for each of the 23 selected varieties grown in this way, it is seen that a Barbados seedling, B. 208, yielded

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the largest amount of sucrose per acre; another Barbados seedling, B. 156, which stands third on the list, exceeds the former in the amount of cane produced per acre. In a second table (No. 36), which gives the means for plant-canes cultivated on 6 to 8 plots in St. Kitts, B. 208 figures second on the list; the variety, "Caledonian Queen," which heads the list, gave a much higher tonnage and a higher percentage of juice per acre, but yielded a juice of inferior quality. Finally, in the table of results obtained with ratoon canes, B. 208 appears second in the list for Antigua, but is much lower in the list for St. Kitts. These facts, when taken in conjunction with the success of the same variety in Barbados and elsewhere, justify the opinion that "B. 208 commends itself highly to planters on account of its good field character and the ease with which sugar can be manufactured from it. It also retains its excellent character when judged as a ratoon cane." In spite of this favourable verdict, Mr. Watts warns planters not to decide too readily for this or any other variety, and reminds them that B. 208 has not been sufficiently long under cultivation—two years—to be accepted as the best variety. This warning is not superfluous when it is remembered that a preliminary trial with the Burke variety gave promising results which were not fulfilled when the plant was taken into cultivation. The Burke cane is also interesting because it furnishes an instance of a variety which has done very well in Antigua but has been a failure in Barbados. And whether it is a matter of soil or physical conditions, or a difference in strain, the same inequality of production may be expected even on different estates in the same island, so that it becomes a matter of importance to grow varieties which have been proved locally successful and to obtain seed or cuttings from well known sources.

Experiments were made to try the effect of applying germicides to cuttings before planting, and ordinary cuttings or pieces of the cane bearing lateral buds only were tried as well as "tops" on which the main growing point is present. These were treated with (1) Bordeaux mixture, (2) tar applied to the ends, and (3) a combination of the two. The treatment was generally beneficial, but the best results were obtained with Bordeaux mixture alone.

In the case of manurial trials, 38 different experiments were devised and set up in duplicate, in which the nature and quantity of the manures were varied. The control plots were dressed with 14 to 20 tons of pen manure, and these were compared with plots treated with a larger quantity of the same manure or with various amounts of nitrogenous manures, phosphates, potash, guano and lime. The results are shown

Sugar-cane Experiments in the Leeward Islands.

very clearly in diagrams in which the amount of sucrose in the juice per acre is represented by a horizontal line, and a break cuts off a proportion of the line which corresponds to the cost per acre of the manure supplied; thus reading the black line to the break gives the payable yield for each experiment. Diagram 2 is the most important as giving the mean results for 3 years for plant or first year canes. The chief results obtained are that an application of about 20 tons of pen manure well worked in is necessary, after which for plant canes artificial manures are not required and will not prove remunerative. The addition of nitrogenous manure or potash increases the yield slightly, but is doubtfully remunerative, while even though the soil in the islands is considered to be deficient in phosphates, the addition of phosphates to the plots receiving potash and nitrogen actually results in a decreased crop. For ratoon or second year canes, in order to obtain the maximum crop, the addition of nitrogenous manure is necessary either in the form of nitrate of soda or sulphate of ammonia, and it is important to add this in one application.

KINO FROM THE BARK OF *DIPTERYX ODORATA.*

It has recently been observed by Messrs. Heckel and Schlagdenhauffen, that, the leaves, stem and fruits of the South American tree *Dipteryx odorata* from which Tonquin beans are obtained, yield a resin with properties very similar to those of Manilla copal (*Bulletin of the Imperial Institute,* Vol. 1., p. 142).

These authors in continuing their investigation of the products of this tree have shown that its bark contains a liquid kino, of which a description is given, in a recent number of *La Revue de Cultures Coloniales* (1904, Vol. xiv. p. 97).

The liquid is found for the most part in the cortical regions of the trunk, and exudes, when incisions are made through the bark of the tree. Experimental incisions made in the late summer, gave very poor yields, but these will be repeated in the spring when it is expected that a better yield will be obtained.

The kino was experimentally examined and compared with other kinos and found to be of fair quality, being completely soluble in warm alcohol, and leaving very little ash on ignition.

The investigation of the mode of secretion of this kino and of the copal resin in the tree is being continued.

THE FIXATION OF ATMOSPHERIC NITROGEN BY CHEMICAL AGENCY.

The inability of most plants to directly assimilate the nitrogen of the atmosphere necessitates the addition to the soil of soluble substances which contain nitrogen in a state of combination. The action of fixing atmospheric nitrogen is known to occur naturally through the agency of bacteria associated with the roots of certain leguminous plants. By the growth of these plants the soil in which they are grown is enriched with soluble compounds the nitrogen of which is available as plant food. The amount of this essential element obtained by this means is necessarily dependent on time and local conditions, and is often insufficient to replace the nitrogen removed from the soil by the cultivation of non-leguminous crops. The use of artificial nitrogenous manures supplies a ready means of improving soils deficient in nitrogen, and the substances mostly used for this purpose at the present time are ammonium sulphate and sodium nitrate. Nitrogenous manures have so far been more expensive than those containing other plant constituents, and for this reason the importance of devising a practical means for utilising the nitrogen of the atmosphere as a source of such manures has long been recognised. It is therefore interesting to note that the substance calcium cyanamide has recently been prepared with the use of atmospheric nitrogen on a commercial scale in Germany and has been placed on the market under the name of "Kalkstickstoff."

During the experimental preparation of cyanides in the electric furnace in presence of free nitrogen, calcium cyanamide was found to be produced. Further, it was found that the same substance could be obtained by heating a mixture of lime or chalk and charcoal at 2,000 deg C—a temperature below that necessary for the formation of calcium carbide—in a current of air. Under these conditions the nitrogen of the air enters into combination, and the principal product of the reaction is calcium cyanamide.

The manurial properties of this substance have been tested by Professors Wagner and Gerlach at Darmstadt and Posen respectively with various crop-plants, and although there is much to learn with regard to the conditions under which it may be most advantageously employed, this material has already proved itself a manurial agent apparently as valuable as amonium salts and nearly as effective as sodium nitrate.

It is considered very probable that if calcium cyanamide can be manufactured cheaply it will find a place among the artificial nitrogenous manures. In this connection it may be mentioned that as cyanide of potash or soda can be readily prepared from calcium cyanamide this material is of interest not only in agriculture but also in the extraction of gold.

NOTICES OF SOME RECENT UNOFFICIAL PUBLICATIONS.

(All these books have been added to the Imperial Institute Library.)

INDIA: OUR EASTERN EMPIRE. By P. H. Gibbs. Pp. viii. + 207. (London: Cassell & Co.)

The greater part of this book is taken up with short descriptions of the principal cities in India, and the portrayal of the special features to be observed by a traveller in Bombay, Madras, and Calcutta. The author describes the situation of the large cities lying on the banks of the Ganges, and recalls some of the events which have made them so noteworthy in the history of British India. To the account of the more important Native States is appended a special map showing the situation and extent of these territories. The chapter on "India's Frontiers" describes the Khyber Pass, and in this connection a photograph of a caravan *en route* gives some impression of the mountainous nature of this country, in addition to illustrating the method of transport. In the two concluding chapters, which are mainly historical, the author traces the origin of the races and religions found in India, while the narration of the most important event of recent times, the Delhi Durbar, is reserved for the close. The book contains numerous illustrations reproduced from photographs.

THE NILE QUEST: A RECORD OF THE EXPLORATION OF THE NILE AND ITS BASIN. By Sir Harry Johnston, G.C.M.G., K.C.B. Pp. xv. + 341, with illustrations and maps. (London: Lawrence and Bullen, Ltd., 1903.)

"The Nile Quest" is the first of a series of volumes on the history of great geographical discoveries issued under the general title of "The Story of Exploration." Beginning with the dawn of Nile exploration under such leaders as the usurper Amasis and the Persian conqueror Cambyses, the author traces the gradual growth of European interest in the Nile question as evidenced in the works of early Greek historians and geographers (Herodotus, Aristotle, and Eratosthenes), and pursues the story of the quest in the accounts of successive Persian, Greek, and Roman adventurers, through the Arab and Jewish researches of the middle ages, to the comparatively modern achievements of the Portuguese travellers of the 16th and 17th centuries. Chapters are devoted to the expeditions of Bruce, the pioneer of British Nile explorers, to the opening up of the White Nile by Muhammad Ali, and to the reports sent home by emissaries of the Church Missionary Society. The volume forms a record of the exploration of the Nile basin during some three thousand years, includes a list of explorers whose researches contributed to the gradual revelation of the course of the great river, and ends with a bibliography of the books referred to in the compilation of the work.

Food for the Tropics: being a Short Description of Native Produce suitable for Food in Tropical Countries. By T. M. Macknight. Pp. ix. + 116. (London, Calcutta, and Bombay: Thacker & Co., 1904.)

Believing that the indigenous products of a tropical country are more suitable as food for the inhabitants than any which can be imported from another country having a totally different climate, the author proceeds to enumerate the various kinds of products of tropical countries, and to explain how they can best be utilised. Each chapter deals with one staple article of food consumed in Europe, such as bread, potatoes, meat, butter, vegetables, or fruit, and shows how every constituent of such food can be obtained in one form or another from native products of tropical countries. The appendices contain tables giving the percentage composition of some articles of food of the temperate and tropical zones, a bibliography, and a list of the best edible fishes of the tropics.

Disinfection and the Preservation of Food, together with an Account of the Chemical Substances used as Antiseptics and Preservatives. By Samuel Rideal, D.Sc. (Lond.). Third Edition. Pp. 494. (London: The Sanitary Publishing Co., Ltd., 1903).

Owing to its important bearing upon the question of public health, the subject of disinfection has received very careful study during recent years, and as a result great progress has been made in this branch of sanitary science. The aim of this book is to provide a convenient summary and review of the extensive literature now available on the subject, which will be of service not only to the sanitary expert, but also to all those concerned in the practical work of disinfection. The third edition of the book has been recently issued, and the opportunity has been taken to revise the whole and to bring the information thoroughly up to date. The different methods of disinfection are fully described and their efficiency compared, after which a detailed account of all the principal disinfecting agents is given, with particulars regarding the specific action of each.

In view of the disputes which have arisen regarding the use of food preservatives, the section upon this subject has been extended and now includes descriptions of the principal methods of preservation in use at the present time, together with a summary of the conclusions arrived at by various committees appointed to investi-

Notices of some rece Unofficial Publications.

gate the question. The author takes the view that under present conditions it appears to be impossible, without incurring great loss, to dispense with the use of preservatives for perishable articles of food, and that in some cases the addition of chemical preservatives may even be desirable, providing proper control be exercised.

The book concludes with a statement of the bacteriological and chemical methods employed in the examination of the various substances used for antiseptic or disinfecting purposes.

A TREATISE ON MANURES; OR, THE PHILOSOPHY OF MANURING. A Practical Handbook for the Agriculturist, Manufacturer, and Student. By A. B. Griffiths, Ph.D. Third edition, revised and enlarged. Pp. xvi. + 453. (London: Whittaker & Co., 1903.)

In this book a short account is given of the nature and composition of each of the numerous materials, both natural and artificial, now employed as manures. It includes an account of the machinery and processes used in the preparation of manufactured manures. The principles of manuring, the analysis and valuation of manures, and other subjects relating to agriculture, are also dealt with though necessarily somewhat briefly.

PLANT-GEOGRAPHY UPON A PHYSIOLOGICAL BASIS. By A. F. W. Schimper. Authorised English translation by William R. Fisher, B.A. Revised and edited by Percy Groom, M.A., D.Sc., F.L.S., and Isaac Bayley Balfour, M.A., M.D., F.R.S. Pp. xxx. + 839. (Oxford: Claredon Press.)

At the present time when so much attention is being paid to the study of ecological botany, some interest attaches to the appearance of a translation of Schimper's "Pflanzengeographie." As those who have perused the German edition will know, the author attacks ecological questions from the physiological standpoint, which he considers the most effective in the endeavour to realise the aim of geographical phytology, viz., the explanation of the differences existing among different floras.

The book is divided into three parts. The first deals with the different factors affecting plant life, the chapters on "Water" and "Soil" being of special interest. In the first of the two chapters of the second part plant formations are considered, of which Schimper distinguishes two ecological groups: the *climatic*, the character of whose vegetation is governed by atmospheric conditions, and the *edaphic*, whose vegetation is chiefly determined by the nature of the soil. The second chapter contains an account of the various plant guilds, including lianes, epiphytes, saprophytes, and parasites. The first and second parts may be considered as introductory to the third, which forms the bulk of the book. This section is concerned with an account of the floristic characters of the great geographical zones.

The volume contains numerous original illustrations.

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THE ELEMENTS OF MINING AND QUARRYING. By the late Sir C. le Neve Foster, D.Sc., F.R.S. Pp. xvi. + 299. (London: C. Griffin & Co., 1903).

This book deals in a concise manner with the general principles underlying modern practice in mining and quarrying. The first chapter treats of the occurrence of the various economic substances which are obtained from the earth's crust, giving examples from typical mines. In chapter two an account of surface indications of minerals is given. Chapters three and four deal with the methods of boring and with excavation by manual labour and machinery. Chapters eight to eleven describe mining equipment, and cover the methods of haulage, hoisting, drainage, ventilation, and lighting. The three concluding chapters deal with mining regulations and with accidents, and the diseases peculiar to workers in mines.

METALLURGICAL ANALYSIS AND ASSAYING. A three years' course for students of schools of Mines. By W. A. Macleod, B.A., B.Sc., A.O.S.M. (N.Z.), and Chas. Wilken, F.C.S. Pp. xii. + 318. (London: Charles Griffin & Co , Ltd., 1903.)

This is a text book of a comprehensive character. Detailed instructions for the qualitative and quantitative analysis of inorganic substances are contained in Parts I. and II., where all the methods in common use are described. Part III. is divided into two sections, of which the first deals systematically with the assay of the principal ores, while the second is devoted to technical analyses, including those of water, furnace gases, coal, cement, and petroleum.

The book assumes no previous knowledge of practical chemistry, and contains full directions for the work of students.

OUTLINES OF GEOLOGY: AN INTRODUCTION TO THE SCIENCE FOR JUNIOR STUDENTS AND GENERAL READERS By James Geikie, LL D , D.C.L , F.R.S Fourth edition, revised. Pp. xii. + 424. (London. Edward Stanford, 1903)

This is, as its title implies, an elementary manual of Geology. It describes in turn the chief geological agencies and the results of their operations The principal minerals and rock types and the structures of the latter are next dealt with, a special chapter being devoted to ore deposits and their mode of occurrence. The concluding chapters are concerned with stratigraphical geology, and contain descriptions of the more important formations and the fossils that characterise them. There are numerous illustrations.

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MINERAL SYSTEMS.—A review with outline of an attempted classification of minerals in natural groups. By E. J. Chapman, Ph.D. Pp. ix. + 144. London: Williams & Norgate, 1904.

The author proposes a new classification of minerals in which less attention is paid to the chemical composition and more to physical characters than has usually been the case. Some notes on blowpipe reactions are appended.

THE CYANIDE PROCESS OF GOLD EXTRACTION. By James Park. Pp. xiv. + 187. (London: C. Griffin & Co., 1904.)

The extraction of gold by means of a dilute solution of potassium cyanide as applied to tailings from free milling ores is a simple matter, but the modifications which are necessary in the case of sulphide, telluride, and other gold ores tend to complicate the process, and to make it one of the most difficult of wet methods of extraction. The recovery of the gold, either direct from the cyanide solution or by precipitation by means of zinc, has been much improved in recent years, with the result that lower grade ores can now be successfully treated. All these features of the process receive attention in this book. Commencing with the chemistry of the process, the author describes the necessary appliances which are illustrated by large scale drawings. Succeeding chapters deal with the treatment of slimes and concentrates, and the recovery of gold by zinc precipitation. Finally an account is given of the numerous variations of this process in vogue at mines in the Colonies and America.

THE OIL FIELDS OF RUSSIA AND THE RUSSIAN PETROLEUM INDUSTRY.—A practical handbook on the exploration, exploitation, and management of Russian oil properties. By A. Beeby Thompson, A.M.I. Mech.E. Pp. xviii. + 504. (London: Crosby, Lockwood & Son, 1904.)

This book deals with the development and present condition of the mineral oil industry in the Caucasus.

The author describes in some detail the geological structure of the country and the curiously irregular flow of the oil underground, and discusses the theories that have been put forward to account for its formation, but leaves the impression that there is still much to learn on the subject.

The conditions in the Caucasus are very dissimilar to those that prevail in most mineral oil-producing regions, and as the result of long experience and repeated experiments methods and machinery have been evolved which differ widely from those in use elsewhere. They will be found described at length in the present work, but the strata are so variable and the difficulties to be overcome so numerous and diversified, that even this bulky volume does not exhaust the technical details of the subject.

Considerable space is devoted to the methods of boring and casing the wells and to the important matter of the exclusion of water, the presence of which has most unfortunate results on the yield. The method of baling by means of long cylindrical buckets is clearly described, as well as the author's "air lift." By the use of the latter the oil is raised with much less trouble and expense; but it is only applicable when the well is at least half full of oil.

A description is given of the fountains of oil which rise to a height of over 400 feet and sometimes become towering columns of fire.

The book is well provided with statistics and statistical diagrams; and detailed figures of the different fields as well as of the principal properties in each. A complete table of equivalents of Russian moneys and weights is given in the Appendix.

There are numerous illustrations, reproduced from photographs, and several maps.

INDIAN AND COLONIAL COLLECTIONS.

RECENT CHANGES AND ADDITIONS.

The Indian and Colonial Collections of the Imperial Institute are devoted to the illustration of the economic products and commercial resources of India and the Colonies. These Collections are contained in the galleries situated behind, and running parallel to the main building of the Institute. The arrangement is geographical, the galleries being divided into "courts" each of which is assigned to one particular colony.

Representative exhibits of the products of many of the Colonies have been available to the public for some time, whilst others are now being arranged.

Many of the Courts are at present receiving additions and undergoing complete re-organisation and re-arrangement, in co-operation with the Colonial Governments, in accordance with a general scheme to render them of greater value for technical purposes and as a means of extending general knowledge of the Colonies and their economic resources, and of assisting persons desirous of proceeding to the Colonies in gaining information about the conditions and mode of life there, as well as for illustrating the progress of applied science in the utilisation of economic products.

General information regarding each colony is being provided by means of geographical, geological and meteorological maps and special maps indicating the distribution of the principal crops, minerals, etc.; whilst specially prepared tabular statements are employed to illustrate data supplied by the Governments concerned regarding area, population, revenue and expenditure, and trade, with details relating to the values of the more important products. The specimens of the products are classed in the first instance as vegetable, animal or mineral, and subdivided according to their uses; vegetable products falling into such groups as food-stuffs, timbers, gums, resins, and drugs.

As far as possible samples of the finished article as produced in the Colony will be exhibited together with the raw material, and intermediate stages. Photographs are employed to illustrate characteristic scenes in the cultivation, collection or manufacture of products, and by means of special labels concise information is provided as to properties, uses and supply.

When this work is completed it is hoped that each Court will give an accurate representation of the economic resources of a Colony, and that the Collections will prove an important factor in extending public knowledge of the Colonies, and in furthering their economic development.

NEW SOUTH WALES COURT.

EUCALYPTUS OILS.

An extensive and interesting exhibit of the eucalyptus oils of New South Wales has been presented to the Imperial Institute by the Technological Museum, Sydney, and is now arranged and available to the public in the New South Wales Court in the Exhibition Galleries.

For several years Messrs. R. T. Baker, F.L.S., and H. G. Smith, F.C.S., respectively Curator and Assistant Curator of the Technological Museum, Sydney, have been engaged in investigating the eucalypts of the State, especially in regard to their essential oils. The results of their work have appeared in numerous papers contributed to the Royal and Linnean Societies of New South Wales, and in 1902 a comprehensive summary of the investigation was published officially under the title "A Research on the Eucalypts, especially in regard to their Essential Oils." This volume contains a full account of the botanical and chemical characteristics of all the species investigated and is copiously illustrated throughout, the botanical plates being drawn from the material used in the work.

As Messrs. Baker and Smith state in the preface to their book, the investigation was undertaken owing to the lack of knowledge of the eucalypts of the State, and with the view of assisting the commercial utilization of the oils, which at the time appeared inferior in quality to eucalyptus oils obtained from Tasmania, Victoria, and South Australia.

One of the most interesting facts ascertained during this research, and one of great economic importance, is that the oil obtained from many of the species possesses certain definite constituents and properties which are constant, no matter where the trees are grown For this reason it is important to restrict commercial operations to those species whose oils are proved to be of good quality and to keep the products of individual species distinct If this is done, the quality of any eucalyptus oil can be assured and an industry built up of a product the name of which should be a guarantee of the constancy of the constituents, so that the purchaser may be sure of obtaining what he requires. Nothing can be more detrimental to the industry than the indiscriminate mixing of the leaves of various eucalypts.

The deserved prominence obtained by the oils of *Eucalyptus globulus*, *E. cneorfolia*, and a few other species which have been so extensively distilled in the past, is apparently due rather to the perseverance and persistency of the companies working these oils than to any superiority of the oils themselves. Some

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other species, *e.g.*, *E. Smithii*, are now brought forward as yielding oil of very high quality and possessing other characters of commercial value.

During the progress of the research Messrs. Baker and Smith were led to revise the usually accepted classification of the genus and the species, as described, are found on the characters of barks, timbers, the chemical and physical properties of the oils, and field knowledge, in addition to morphological characters. Species constituted on this broader basis are found to be practically constant in their botanical and chemical characteristics, however great their geographical range, a point obviously of considerable economic importance.

Of the 120 species of eucalypts occurring in New South Wales, about 111 have been investigated, and as many of these also occur in other States, much of the work is really of direct value for the whole Commonwealth; and it is now possible to state with considerable accuracy what the quantity, composition, and probable value of the oil obtainable from any given species would be.

The exhibit in the New South Wales Court comprises samples of the oils and specimens of foliage, flowers, fruits, timber, and bark of the greater number of the species examined. The yield and the principal constituents of each oil are given on the labels, and for those desiring more information, the papers published by the investigators are available in the library of the Institute, and can be seen on application at the Central Stand in the Exhibition Galleries.

The exhibit is divided into four classes, according to the composition of the oils. The following notes refer to the species yielding oils richest in eucalyptol; the remaining classes will be dealt with later.

Class 1.—Oils richest in Eucalyptol.

E. hemilampra, *F.v.M* "Mahogany."

The crude oil is reddish-brown in colour, and its odour resembles that of oils belonging to the better class. Specific gravity of crude oil 0·9282; specific rotation $[a]_D = + 7{\cdot}64^{\circ}$. 78 per cent. of the oil distilled between 169° and 183° C., and contained 43 per cent. of eucalyptol.

E. resinifera, Sm. "Red or Forest Mahogany,"

One of the largest forest trees of the State, found throughout nearly the whole of the coast district of New South Wales. The crude oil is dark lemon coloured; the first fraction contained 50 per cent. of eucalyptol. The average yield of oil was 0·302 per cent.

Eucalyptus Oils of New South Wales.

E. polyanthema, Sieb. "Red Box."

A good timber tree found in New South Wales and Victoria. Average yield of oil 0·825 per cent. The crude oil is of a light amber colour, has an odour resembling the better class eucalyptus oils, is rich in eucalyptol and contains some pinene, but no phellandrene. The oil may be considered good, except that esters are present in rather large amount.

E. Behriana, F.v.M. "Mallee Gum."

A small tree of the "mallee" country, ranging through New South Wales, Victoria, and South Australia. The average yield of oil was 0·614 per cent. The crude oil is reddish brown, with the odour of better class eucalyptus oils, fairly rich in eucalyptol, and containing pinene, but no phellandrene. The specific gravity of the oil was found to be high, 0·9237, whereas the amount of eucalyptol present was only moderate, and this oil is cited as an illustration of the fallacy of the supposition that a high specific gravity indicates a high content of eucalyptol.

E. pendula, A. Cunn. "Red Box."

Found in South Australia, Victoria, New South Wales, and Queensland.

Average yield of oil 0·67 per cent It contains eucalyptol and pinene

E. dealbata. A Cunn, "Cabbage or Mountain Gum."

Occurs in New South Wales and Queensland. The crude oil is of the colour of olive oil. The oil is a good eucalyptol one, and may almost be considered to rank with the best. The average yield of oil was 0 856 per cent.

E. rostrata, Sch. var. *borealis*, R.T.B. and H.G.S. "River Red Gum."

Average yield of oil 1·001 per cent. This oil belongs to the eucalyptol pinene group, and is quite different from that obtained from material from another source, but apparently identical so far as morphological characters are concerned. Cattle have long been known to eat the leaves of only one kind of "River Gum" (*E. rostrata*). The variety *borealis* has, therefore, been founded on chemical grounds and awaits further morphological investigation.

The oil is rich in eucalyptol, and the leaves might be distilled commercially, whereas the oil could not be extracted profitably from *E. rostrata*, which yields only a small quantity of eucalyptol.

E. maculosa, R.T.B. "Spotted Gum."

A eucalyptol-pinene oil. Average yield of oil 0·846 per cent.

Eucalyptus Oils of N. South Wales.

E camphora, R.T.B. "Sallow or Swamp Gum."

Usually found in swampy or wet ground, and obtained from ew South Wales and Victoria, but not from Tasmania. The verage yield of oil obtained was 0·836 per cent. The crude il is amber coloured. Eucalyptol is present in abundance. inene is present, but phellandrene absent. Eudesmol was lso found to be present; one sample of oil containing such a arge quantity of this constituent that the fraction crystallised n the receiver soon after distillation. The season of the year ppears to exercise an important effect on the formation of udesmol, and it is suggested that it may be an intermediate roduct in the formation of eucalyptol. This may be regarded s an excellent eucalyptol oil.

E. punctata, Dc. "Grey Gum."

Coast district of New South Wales and Queensland. Average ield of oil 0·781 per cent. The oil belongs to the eucalyptol-inene group.

E. squamosa. D. & M. Ironwood."

An excellent eucalyptol oil; average yield 0·643 per cent.

E. Bridgesiana, R.T.B "Apple or Woollybutt."

The crude oil obtained from this species is orange-brown in olour and rich in eucalyptol. It is an excellent oil, but nfortunately the yield is not large, and for this reason it may ave to be excluded from the list of those available for commercial distillation of oil.

E. goniocalyx, F.v.M. A "Mountain Gum."

This species yields an oil rich in eucalyptol, but containing olatile aldehydes, so that it should not be used medicinally ithout rectification. The average yield of oil was 0·881 per ent.

E. bicolor, A. Cunn. "Bastard Box."

This oil is rich in eucalyptol, the amount present in the first raction, between 171 and 183° C., being 70 per cent.

E. populifolia, F.v.M. "Poplar-leaved Box."

The oil is rich in eucalyptol.

E. longifolia, Lin. K. "Woollybutt."

Average yield 0·535 per cent. Oil rich in eucalyptol.

E. maideni, F.v.M. "A Blue Gum."

This species is closely related to *E. globulus*, and the oils of the two species are very similar in composition. The oil is rich in eucalyptol and the species may be considered a good one for commercial purposes, but it would be necessary to rectify the oil by re-distillation owing to the presence of esters and volatile aldehydes. Average yield of oil 1·304 per cent.

E. globulus, Labill. "Blue Gum."

This well-known species ranges from Tasmania through the south-eastern part of Australia; but although it occurs in New South Wales, its distribution there is against its being largely used for oil distillation. It is extensively planted in various parts of the world, and oil distilled from it in Algeria now enters largely into competition with the Australian product. It is important to notice that the oil obtained from plants grown in New South Wales is the same in character and constituents as that always obtained from this species wherever grown. The average yield of oil is given as 0·745 per cent.

E. pulverulenta, Sims.

The oil of this species is exceedingly rich in eucalyptol, the first fraction distilled between 166 and 183° C. containing 60 per cent. The average yield of oil is also very high no less than 2·22 per cent. The plant is, however, rare.

E. cinerea, F.v.M. "Argyle Apple."

This species yields an excellent eucalyptol oil, which is at present distilled on a commercial scale in the State. The plant is gregarious and bears plenty of foliage, yielding a large percentage (1·2) of oil; it is thus well adapted to commercial purposes. The oil contains valeric ester in some quantity, and the iron or copper stills employed are often attacked, causing the crude oils to be tinted red or green as the case may be. The iron does not appear in the distillate on rectification, and the use of copper stills has been discontinued.

E. cordata, Labill.

A Tasmanian species, giving the high average yield of 2·32 per cent. of oil rich in eucalyptol.

E. Stuartiana, F.v.M. "Apple."

The yield of oil is low, only 0·394 per cent.

E. Morrisii, R.T.B. "Grey Mallee."

An excellent eucalyptol oil, and as the average yield is high, 1·69 per cent., this species is regarded as an excellent one for commercial oil distillation.

E. Smithii, R.T.B. "Gully Ash or White Top."

This species is regarded as one of the best sources of eucalyptol oils for the following reasons: (1) the yield of oil

Eucalyp Oils of N South Wales.

from "sucker" and mature leaves is large; (2) the oil from sucker and mature leaves is of equal value; (3) the oil is exceedingly rich in eucalyptol, the crude oil containing 70 per cent.; (4) constituents of high boiling point are absent; (5) the rectified oil is of superior quality owing to the absence of esters and volatile aldehydes; (6) the loss sustained on rectification is small.

It is suggested that young plantations of this species could be utilised, and that by systematic cultivation the difficulty of collecting leaves from mature trees might be avoided.

E. sideroxylon, A. Cunn. "Red Flowering Iron Bark."

This oil belongs to the eucalyptol-pinene group, and is of excellent quality. The average yield obtained was 0·537 per cent.

E. Cambagei, D. & M. "Bastard Box or Bundy."

Average yield 0·735 per cent. The oil is rich in eucalyptol, and contains pinene and a small amount of aromadendrol.

E. polybractea, R.T.B. "Blue Mallee."

Average yield low, 0·135 per cent. The oil belongs to the eucalyptol-pinene group, but like those of most of the other mallees also contains aromadendrol.

E. dumosa, A. Cunn. "White Mallee."

Average yield of oil about 1·0 per cent. This is a fair eucalyptol oil, containing aromadendrol, but terpenes are also present.

E. oleosa, F.v.M. "Red or Water Mallee."

A eucalyptol-pinene oil with aromadendrol. This species has a wide distribution, occurring in Queensland, Victoria, South Australia, Western Australia, and the south and western interior of New South Wales.

E. cneorifolia, D.C.

A South Australia species from Kangaroo Island.

E. stricta, Sieb. "Mountain Mallee."

Average yield of oil 0·494 per cent. Constituents of high boiling point are only present in small quantity, and the oil is very rich in eucalyptol.

E. mellidora, A. Cunn.

This oil contains eucalyptol and pinene, with often phellandrene in addition. The average yield was 0·676 per cent.

NEW ZEALAND COURT.

The re-organisation of the New Zealand Court has been undertaken with the co-operation of the Agent-General for the Colony. It is hoped that in the near future new exhibits will be added to make the Court more fully illustrative of the products and resources of the colony, but for the present the commercial and educational value of the collection has been considerably increased by the rearrangement of the exhibits, and by the provision of specially prepared descriptive labels for the existing specimens.

Two large coloured wall maps have been added, accompanied by a summary of the principal physical features and economic products of the Colony.

Seventeen large photographs have also been provided, comprising views of the Waimangu Geyser; the Champagne Pool, Wairakei; the Mangapapa Falls; the Wanganui River; Maoris, Maori dwellings and the Maori Monument to the late Queen Victoria. These photographs, together with those previously in the Court, and the series of water colours presented by Mr. S. Moreton, afford representations of the principal types of scenery of the Colony.

Timbers.

New Zealand is remarkably rich in forests containing large quantities of excellent timber. It is estimated that the forest lands of the Colony comprise 20,500,000 acres. The forests are usually of a mixed character, with one or two kinds of trees predominating to a greater or less extent, and large areas of forest seldom consist of a single species only.

All the forests are now controlled by the Department of Lands and Survey, and nurseries have been established which are estimated to produce annually over 1,500,000 young trees for re-afforestation purposes. The State Forest Reserves comprise over one million acres. The following are the more important timbers, specimens of which are exhibited in the Court, with full information regarding their source, uses, sizes procurable, approximate prices, &c. Specimens of parquetry work, picture frames, and other articles made of New Zealand woods, indicate some uses to which they can be applied.

Kauri. (*Agathis australis.*)

The most valuable timber tree of New Zealand. It is restricted to the northern end of North Island, and is rare at elevations above 1,500 feet.

Kauri wood is yellowish white to brown in colour, straight grained, compact, strong and elastic. It is easy to work, and takes a high polish. Planks, 4 to 5 feet wide and 20 feet in

Timbers of New Zealand.

length, are exhibited, as well as smaller specimens. Kauri is extensively employed for general building purposes, joinery and cabinet-making, bridge and wharf work, spars, &c. For special purposes "waved" and "mottled" Kauri are much in demand. Specimens of these are also shown.

During the three years, 1899-1902, 126,000,000 superficial feet of Kauri timber were exported from New Zealand, and the value of this timber cut annually for home use or for export is stated to be about 400,000*l.* Its approximate price, f.o.b., per 100 superficial feet, 1 inch thick, is 16*s.* for long lengths.

Rimu or **Red Pine.** (*Dacrydium cupressinum.*)

This tree occurs throughout the Colony, and occupies a larger area than any other native timber tree The wood is of a handsome deep red colour, with dark or light markings, and tests have shown it to be equal to English oak in strength.

Throughout two-thirds of New Zealand "Rimu" is the chief timber employed for general building purposes, and although less valuable than Kauri or Totara its adaptability to a larger number of purposes renders it the most important commercial timber of the Colony.

Rimu is obtainable in long lengths, and up to 24 inch widths. Its approximate price for 100 superficial feet, 1 in. thick, f o.b., is 8*s.* 6*d.*, all heart.

Totara. (*Podocarpus Totara.*)

Widely distributed throughout the Colony, but most abundant in North Island. The timber is of a deep red colour, approaching in some specimens the tint of Honduras mahogany, compact, straight in the grain, not liable to warp or twist, and easily worked Totara timber is excellent for general building purposes, and owing to its power of resisting attacks of the teredo is specially valued for marine piles and wharf work.

Occasionally the wood is handsomely mottled and figured, and choice specimens so marked are in demand for ornamental work. Some very fine specimens of mottled Totara are exhibited in the Court.

Totara is obtainable in long lengths and up to great widths; approximate price, f o.b., per 100 superficial feet, 1 inch thick, is 15*s.* all heart; 13*s.* first-class building timber.

Kahikatea or **White Pine.** (*Podocarpus dacrydioides.*)

This timber is white, or sometimes pale yellow, in colour, tough, strong, straight in the grain, light, and very durable when kept free from damp. It takes a high finish, and polishes readily, and is largely employed in the Colony for interior work, whitewood furniture, packing cases, butter boxes, tallow casks, &c. Its approximate price f.o.b. per 100 superficial feet is 6*s.* 6*d.*

Matai or **Black Pine.** (*Podocarpus spicata.*)

A tree widely distributed throughout New Zealand. The timber varies in colour from light to deep brown, and is of smooth, even texture and great strength and durability. Although close grained it is easy to work. Matai is suitable for general building purposes, especially lining and weather boarding, joinery and cabinet-making. It is stated to have a special application as a flooring wood in public buildings on account of its wear-resisting properties and the fine glossy surface it attains with age. The timber can be obtained in long lengths and up to 24 inch widths. The approximate price per 100 superficial feet, all heart, f o.b., is 10*s*.

Silver Pine or **Westland Pine.** (*Dacrydium westlandicum.*)

This timber tree occurs principally on the west coast of Middle Island, where its value has been recognised since the earliest settlements. The wood is yellowish-white, dense, has a straight, even grain and satiny lustre, and takes a high finish. It is very tough and extremely durable. Silver pine is extensively employed for bridges, wharves, sleepers, mining timbers, and in building and joinery. Mottled and waved specimens are very handsome, and are used in cabinet-making, &c. Planks are obtainable up to 20 feet long and 15 inches in width, and the approximate price per 100 superficial feet, f.o.b., is 16*s*.

Tawhai or **Black Birch.** (*Fagus fusca.*)

Although known locally as a "birch," this tree is closely related to the European beech, and is found throughout the colony. The wood is red, straight, even, and compact in the grain, tough, and durable. Its principal uses are for railway sleepers, piles, stringers, bridge and wharf planking, and mining timbers. Long lengths, and widths up to 24 inches, are obtainable, and the approximate price per 100 superficial feet, f.o.b., is 11*s*.

Rewa Rewa, or **Honeysuckle.** (*Knightia excelsa.*)

Occurs throughout North Island and the northern portion of Middle Island. The wood is red in colour and beautifully mottled. Although of great strength, it is found to be lacking in durability when exposed to the weather. The handsome appearance of this wood and the great variety of its markings render it specially adapted to ornamental cabinet work, as is well illustrated by specimens of parquetry and picture frames exhibited in the court.

Lengths up to 20 feet and up to 24 inches in width are obtainable, and the approximate price per 100 superficial feet, f.o.b., is 15*s*.

Timbers of New Zealand.

Puriri, or New Zealand Teak. (*Vitex littoralis.*)

The strongest of all New Zealand timbers, restricted to the northern portion of North Island. The wood is dark brown in colour, excessively hard, dense, heavy, of great durability, but somewhat difficult to work. Puriri is used for house blocks, piles, railway sleepers, machine beds and bearings, and other purposes demanding strength and durability. It is also employed to some extent in ornamental cabinet-making.

The supply of this timber has been exhausted in some districts where at one time it was plentiful, and it is now becoming scarce. Material is obtainable up to 20 feet in length and 15 inches in width, at an approximate price, f.o b., of 20*s*. per 100 superficial feet.

Maire-rau-nui, or Black Maire. (*Olea Cunninghamii.*)

This timber ranks next to puriri in strength, and like it is restricted to North Island. The wood is of a deep brown colour, the heart wood being often streaked with black. It is highly ornamental, heavy, dense, compact, straight in the grain, easily worked, and very durable. Maire is chiefly employed in framing for machinery, wheelwrights' work, and ornamental cabinet work of all descriptions. It is obtainable in lengths up to 20 feet, and 15 inches in width, and its approximate price per 100 superficial feet, f.o.b., is 15*s*.

Rata. (*Metrosideros robusta.*)

The wood of Rata is red in colour, hard, dense, straight grained, and of great strength and durability. It is used for arms of telegraph posts, railway carriage and wagon frames, wheelwrights' work, machine beds and bearings, &c. Long lengths and widths up to 48 inches are obtainable, the approximate price being 14*s*. per 100 superficial feet, f o.b.

Manuka, or Tea Tree. (*Leptospermum ericoides.*)

A dense, straight grained, elastic, red coloured wood, of value for wheelwrights' work, inlaying, &c. Short lengths only and of small size are available; the approximate price is 14*s*. per 100 superficial feet.

Titoki. (*Alectryon excelsum.*)

This tree is found in North Island and the northern portion of South Island. The timber is of a bright red colour, straight grained and of great strength, toughness and elasticity. It is employed for wheelwrights' and coach builders' ware, axe handles, and similar articles. Long lengths and up to 24 inches in width are obtainable, the approximate price being 18*s*. per 100 superficial feet, f.o.b.

Akeake. (*Olearia avicenniæfolia.*)

A yellowish wood, with satiny lustre frequently waved and prettily figured, used for ornamental cabinet work, inlaying, &c. Only short lengths of small size are to be had; the approximate cost is 100*s.* per 100 superficial feet, f.o.b.

Kowhai. (*Sophora tetraptera.*)

A pale brown, compact, heavy wood, of great strength, toughness and elasticity; employed for bearings for shafts and machinery, swingle-trees, teeth and bows of hay rakes, and cabinet work. Short lengths, and up to 12 inches in width are obtainable, the approximate price being 20*s.* per 100 superficial feet, f.o.b.

Mangeao. (*Litsea calicaris.*)

This wood is obtained in the north of North Island. It is white, firm, strong, and of great elasticity, and suitable for a great variety of purposes demanding strength, toughness and elasticity combined with light weight, such as ship's blocks, coopers' ware, and wheelwrights' bent stuff. It can be obtained in lengths of 25 feet and up to 18 inches wide; the approximate price is 20*s.* per 100 superficial feet, f.o.b.

KAURI-RESIN.

Kauri-resin, or Kauri-gum as it is often incorrectly termed, is an exudation from the Kauri Pine (*Agathis australis*).

Some resin is obtained from living trees, but it is much inferior in quality to that found in the ground in the "fossil" condition Some 7,000 persons, known as "gum-diggers," are employed in searching for Kauri-resin. The lumps vary considerably in size and colour, the transparent or semi-transparent pieces being the most valuable. The resin obtained from swampy districts is dark coloured and sometimes nearly black. Before being placed on the market the lumps are scraped, in order to remove the rough, discoloured exterior, the scrapings being carefully collected and sold as a special grade.

Kauri-resin is extensively used in the manufacture of varnishes, and is exported chiefly to the United Kingdom and to the United States. The varnish is prepared by heating the resin just to the melting-point, and then pouring it into hot linseed oil. The transparent varieties of the resin are employed in the manufacture of cigar-holders and in other ways as a substitute for amber.

The value of Kauri-resin exported from New Zealand has largely increased during recent years, the increase being chiefly due to the rapid advance in price which has taken place.

The representative exhibit of the resin in the New Zealand Court has recently been examined by an expert, who has graded

Kauri-Resin. and priced the various specimens shown. The chief varieties are:—"Pale Amber," re-scraped; "Dark Amber"; "Brandy Gum"; "Swampy Gum" (a quality in considerable demand at the present time for inferior varnishes, owing to the high prices of superior grades); "Tree Gum"; "Rough Chips from Re-scraped White Amber" (small pieces broken off good gum by handling and packing); and "Amber Seed" (obtained in the scraping of good quality gums). Polished specimens illustrate the ornamental uses to which Kauri-resin is applied.

LIBRARY.—RECENT ADDITIONS.

Books and Publications, exclusive of Government Publications, presented by Publishers and others to the Library of the Imperial Institute since 30th June, 1904.

Museum Report, 1893-1902 ... ... Catalogue of the Hanbury Herbarium, 1892 Catalogue of Medicinal Plants, 1896 ...		*(The Curator of the Pharmaceutical Society's Museum.)*
Chapters on Paper-making	By Clayton Beadle.	*(H. Grattan.)*
Manual of Forestry. Vol. II.	By Prof. Schlich.	*(Messrs. Bradbury, Agnew & Co.).*
Geography Reader...	By V. T. Murché.	*(The Author.)*
Drugs	By H. Wippell Gadd.	*(The Author.)*
Recent Improvements in Sewage Treatment	By W. J. Dibdin.	*(Sanitary Publication Co.)*
Handbook to the Ceylon Court at the St. Louis Exhibition		*(Messrs. Cassell & Co.)*
The Khedive's Country	By G. Manville Fenn.	*(Messrs. Cassell & Co.)*
Transactions of the Institute of Mining and Metallurgy. Vols. I. to X.		*(The Secretary).*
Proceedings of the Royal Society of Queensland. Vol. 18. 1904		*(The Secretary).*

Sugar Cane in Egypt	By F. Tiemann.	*(Publishers of the International Sugar Journal.)*
The Ancient City of Canterbury		*(The Mayor of Canterbury.)*
Proceedings of the Royal Colonial Institute		*(The Secretary).*
The Congo	By R. de Mares.	*(The Author.)*
Catalogue of the British Section at the St. Louis Exhibition		*(The Secretary of the Royal Commission).*
Tea Soils of Assam	By H. Mann.	*(The Author.)*
Tea Soils of Cachar and Sylhet	By H. Mann.	*(The Author.)*
Kamba and Kikuyu Vocabularies	By H. Hinde.	*(Messrs. C. J. Clay & Sons.)*

SCIENTIFIC AND TECHNICAL DEPARTMENT.

I.—REPORTS ON RECENT INVESTIGATIONS.

RUBBERS AND RUBBER VINES FROM THE EAST AFRICA PROTECTORATE.

The Scientific and Technical Department of the Imperial Institute has already examined a number of specimens of rubber and rubber-yielding trees from the East Africa Protectorate, for the purpose of ascertaining the botanical identity of the plants, and the quality and value of the rubber furnished by them, and two reports upon the subject have already been published. (*Imperial Institute Bulletin*, 1903, Vol. I., pp. 68 and 70). In continuation of this enquiry a number of other specimens have been received at the Imperial Institute for similar investigation, and the following reports embody the results which have been obtained in their examination.

I.—SPECIMENS FROM TAKAUNGU.

These specimens of rubbers and rubber-vines were forwarded to the Imperial Institute by the Commissioner of the East Africa Protectorate in July, 1903. The specimens previously examined included three rubber-vines from Takaungu, named "Mbungu," "Vipo," and "Impira" respectively, but these were accompanied by only one sample of rubber. The "Mbungu" and "Vipo" vines were identified at Kew as *Landolphia petersiana*, whilst that known as "Impira" proved to be *Landolphia Kirkii*, but no information was supplied to show from which of the two vines the rubber had been obtained.

The specimens now under notice are stated to represent the vine which occurs in considerable quantities near Takaungu, and the rubber which it furnishes. Three large specimens of the stems, leaves and fruits of the vine, and also a number of the flowering shoots, were forwarded for examination, together with two samples of rubber.

The botanical specimens were referred for identification to the Director of the Royal Botanic Gardens, Kew, who reported that they all belonged to the same species of Landolphia, viz., *Landolphia Kirkii*. The plant is therefore identical with the "Impira" vine previously forwarded, but no vernacular name was mentioned in this case.

The two samples of rubber were labelled "Sokoki" and "Mtoni" respectively, and it is presumed that both of them represent the product of *Landolphia Kirkii*.

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"*Sokoki*" *rubber.*

The specimen consisted of five balls of rubber, each about 2½ inches in diameter, and together weighing 750 grams. The balls had evidently been formed by winding threads of rubber upon a central mass. They were of a light-brown colour externally, but creamy-white and slightly moist within, and contained only a small amount of foreign vegetable matter. The rubber was not sticky, and exhibited very good physical properties.

"*M'toni*" *rubber.*

This sample consisted of six balls, together weighing one kilogram, which were almost identical in appearance and character with the preceding specimen. The only noticeable difference was that the "M'toni" rubber contained a considerable amount of foreign matter in the form of sand, which was chiefly present in the external layers, and had evidently been included with the rubber during collection.

The chemical examination of the two rubbers in the Scientific and Technical Department of the Imperial Institute gave the following results, the sample of the "M'toni" rubber being selected so as to represent its average composition.

	"*Sokoki*" *rubber.*		"*Mtoni rubber.*"	
	Sample as received. Per cent.	Calculated for dry material. Per cent.	Sample as received. Per cent.	Calculated for dry material. Per cent.
Moisture	11·7	—	9·1	—
Caoutchouc	78·9	89·4	78·2	86·1
Resin	6·8	7·7	4·1	4·5
Dirt	2·6	2·9	8·6	9·4
Ash (included in dirt)	0·87	0·98	8·5	9·3

These results show that, so far as chemical composition is concerned, both samples are of good quality. The dry "Sokoki" rubber contains nearly 90 per cent. of caoutchouc and 7·7 per cent. of resin, and had it not been for the large amount of sand present in the "M'toni" rubber this would have given better figures than the above, as the percentage of resin (4·5 per cent.) is less than that usually found in Landolphia rubbers. Great care should be exercised in the collection of rubber in order to avoid the inclusion of foreign matter, either vegetable or mineral, as the presence of considerable amounts of such impurities, as in the "M'toni" rubber, would diminish the value of commercial consignments.

The two rubbers were submitted to brokers for commercial valuation, the sample of "M'toni" rubber selected for this

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purpose being nearly free from sand in order that the quotation might represent the value of a properly-prepared specimen. The brokers reported that they considered both samples to be worth from 3*s*. 2*d*. to 3*s*. 3*d*. per lb. in the London market, fine Para being then quoted at 4*s*. 3*d*. per lb.

II.—SPECIMENS FROM THE KAMASIA HILLS, NAIVASHA PROVINCE.

Botanical specimens of the leaves and fruits of a rubber vine growing in the Kamasia Hills and also a very small sample of the rubber obtained from it were forwarded to the Imperial Institute by the Commissioner of the East Africa Protectorate in August, 1903.

The leaves and fruits were identified at Kew as belonging to *Landolphia Kirkii*, and the vine is therefore identical with that forwarded from Takaungu.

The sample of rubber consisted of eight small pieces, the total weight of which was only about 30 grams. The rubber was dark reddish-brown externally, but lighter in colour and slightly moist within, and contained a fair amount of foreign vegetable matter. It was not sticky, and exhibited fair elasticity and great tenacity.

The chemical examination furnished the following results:—

	Sample as received. Per cent	Calculated for dry material Per cent.
Moisture	10·8	—
Caoutchouc	68·3	76·6
Resin	11·5	12·8
Dirt	9·4	10·6
Ash (included in dirt)	1·05	1·17

Although this rubber was derived from the same species of vine as the specimens from Takaungu, the analysis shows that it is not of such good quality as these, owing to the much higher percentage of resin present. Like the "M'toni" rubber, it contained a considerable amount of impurity, which in this case consisted of fragments of wood and bark.

The specimen was scarcely large enough to be fully representative, however, and it would be advisable to forward a larger sample, carefully collected and prepared, for further examination. This would enable the composition and quality of the rubber to be definitely ascertained, and the specimen could then be submitted to brokers for commercial valuation, for which purpose the present small sample is not suitable. If properly prepared the rubber would probably be of equal value to the specimens obtained from the same species of vine growing near Takaungu.

III.—Specimens from Rabai.

bers Rubber s from East ca Pro- orate.

This sample of rubber, accompanied by a small specimen of the leaves and fruits of the tree from which it was obtained, was forwarded to the Imperial Institute by the Director of Agriculture, East Africa Protectorate, in September, 1903.

From the small specimen of the leaves and immature fruits it was evident that the plant was a species of Landolphia, but it could not be completely identified owing to the lack of suitable material.

The rubber consisted of a single ball, nearly four inches in diameter and weighing 380 grams. The ball appeared to have been formed by an aggregation of shreds of rubber, and was of a uniform light-brown colour externally, but lighter within, being almost white at the centre; it was rather porous and contained an appreciable amount of foreign vegetable matter. The rubber was not sticky and exhibited very good physical properties.

The results of the chemical examination were as follows:—

	Sample as received. Per cent.	Calculated for dry material. Per cent.
Moisture	4·3	—
Caoutchouc	84·1	87·9
Resin	4·5	4·7
Dirt	7·1	7·4
Ash (included in dirt)...	3·62	3·78

The rubber is therefore of good quality, the percentage of resin being low, but the amount of vegetable matter included might be considerably reduced by more careful collection.

The brokers to whom the rubber was submitted valued it at 3*s*. 3*d*. per lb. in the London market, this being the same price as that quoted for the rubbers from Takaungu.

RUBBER OF *URCEOLA ESCULENTA* FROM BURMA.

A sample of the rubber of *Urceola esculenta* (*Chavanniesia esculenta*) from Burma has been examined already by the Scientific and Technical Department of the Imperial Institute at the instance of the Reporter on Economic Products to the Government of India, and in the report on the previous specimen it was pointed out that the material was of good quality and deserving of further attention by the Forest Authorities (*Imperial Institute Bulletin*, 1903, Vol. I., p. 120). Five other specimens of this rubber, prepared by different methods, were recently forwarded to the Imperial Institute for further investigation by the Reporter on Economic Products.

Rubber Urceola esculenta from Burma.

DESCRIPTION OF THE SAMPLES.

No. 19,747.—This sample, which had been treated with creosote, was forwarded from Bassein, Burma, by the Conservator of Forests. It consisted of four flat cakes, together weighing 55 grams, wihch were dark brown in colour. The rubber was evidently of rather inferior quality, being soft and very deficient in elasticity and tenacity.

No. 19,747-1.—This was of similar origin to No 19,747, but had been prepared with acetic acid in place of creosote. The sample consisted of three circular cakes, weighing 50 grams, which were dark-brown in colour and covered with mould on the surface. In physical characters the rubber was similar to the proceeding specimen.

No. 19,762.—This sample, which had been prepared by the Conservator of Forests in the Pegu Division, Burma, was found to include three distinct forms of rubber, differing somewhat in quality. These were consequently separated and an analysis made of each. For convenience of reference they are marked A, B and C.

A. *Four large rolls, weighing about 530 grams*—The rubber was almost black, very porous, and contained a little vegetable matter and much acid liquid. It was very elastic and tenacious.

B. *Cakes made up of shreds of rubber, together weighing about 450 grams.*—These consisted of aggregations of shreds of rubber of a reddish-brown colour; when cut the cakes were found to be slightly moist and also to contain a small amount of vegetable matter. The rubber was of good quality, being free from stickiness and exhibiting considerable elasticity and tenacity.

C. *Balls of compact rubber, weighing about 480 grams.*—The balls were almost black externally, but when cut they showed irregular white patches scattered through the section, and were rather moist. A quantity of vegetable matter was also present. The rubber exhibited very good physical properties.

No. 19,865-1.—This sample was forwarded by the Conservator of Forests, Pegu Division, Burma. It consisted of two flat cakes, each about six inches in diameter, and together weighing 135 grams. The rubber was dark brown and had a strong odour of creosote; it was slightly sticky, but was strong and exhibited good elasticity and tenacity.

No. 20,583.—This was prepared by the Conservator of Forests, Tenasserim Division, Burma. The sample consisted of two thin sheets of rubber, weighing 25 grams, and having a distinct odour of naphthalene. The rubber had a reddish-brown colour and its physical characters were exceedingly good.

CHEMICAL EXAMINATION.

The analyses of the rubbers furnished the following percentage results:—

	Samples as received.					Calculated for dry material.			
Registered No.	Moisture.	Caoutchouc.	Resin	Dirt and insoluble matter.	Ash, included in dirt.	Caoutchouc.	Resin	Dirt and insoluble matter.	Ash, included in dirt.
19747 ...	1·9	54·0	42·6	1·5	0·64	55·0	43·4	1·6	0·65
19747-1 ...	0·9	52·1	45·5	1·5	0·56	52·6	45·9	1·5	0·56
19762 A ...	11·6	70·7	12·1	5·6	1·86	79·9	13·7	6·4	2·4
Do. B ...	5·9	76·4	10·9	6·8	1·32	81·2	11·6	7·2	1·40
Do. C ...	9·7	73·7	8·3	8·3	2·03	81·6	9·2	9·2	2·24
19865-1 ...	2·6	75·7	18·0	3·7	1·02	77·7	18·5	3·8	1·04
20583 ...	4·0	80·5	9·8	5·7	1·16	83·9	10·2	5·9	1·21

These figures show that numbers 19,747 and 19,741-1 are of very inferior quality, containing 43·4 and 45·9 per cent. of resin respectively in the dry material, and they would therefore only possess a low commercial value. The amount of resin present in these two samples from Bassein is very much greater than in any of the other specimens, and it would be desirable to ascertain the reason of this considerable variation in the quality of the rubber.* The other samples are all of fairly good quality, so far as the chemical composition is concerned, though in No. 19,865-1 from the Pegu Division the percentage of resin is higher than would be desirable in commercial consignments. In the remaining analyses the resin ranges from 9·2 to 13·7 per cent., and the caoutchouc from 79·9 to 83·9 per cent. The three kinds of rubber included in sample No. 19,762 vary slightly in composition, particularly in the amount of resin present.

It may be noted that the sample of this rubber previously examined was found to contain 7·5 per cent. of resin and 81·8 per cent. of caoutchouc, so that although some of the present specimens give a higher percentage of caoutchouc than this, they all contain more resin.

COMMERCIAL VALUATION.

Representative samples of the rubbers, excepting Nos. 19,747 and 19,747-1, which were of much poorer quality than the

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* From later information it appears that the botanical source of these two specimens is rather doubtful and may possibly not be *Urceola esculenta* as was first stated.

Rubber Urceola esculenta from Burma.

others, were submitted for valuation to brokers, who were informed of the results which had been obtained on analysis. They reported that at the present time the value of the specimens in the London market would be as follows:—

Regd. No.	Price per lb	Remarks.
19762 A	About 3*s.* 2*d.*	"Tonquin character."
„ B	„ 3*s.* 6*d.*	"Red Tonquin ball character; inclined to be heated, which would greatly affect its value."
„ C	About 3*s.*	"Dark ball, slightly gummy and not well cured; might be difficult to sell at ordinary times."
19865-1	3*s.* 6*d.*	"Thick biscuit, strong; would command a ready sale."
20588	4*s.*	"Thin sheet, fairly strong; would fetch a good price if not heated."

These valuations are much higher than that obtained for the previous specimen, owing to the fact that all grades of rubber are in strong demand at the present time, and are realising exceptionally high prices. For comparison with the above quotations it may be mentioned that the present value of Para rubber is about 4*s.* 8*d.* per lb. (May 20th, 1904). There does not appear to be any immediate prospect of a fall in price, but should the value of Para rubber decline, all other grades would be correspondingly affected, and in some cases sales would be much more difficult to effect.

It is quite clear, however, from the preceding analyses and valuations that marketable rubber of good quality can be obtained from *Urceola esculenta*, in Burma, and it would be well if a trial consignment could now be forwarded in order that the commercial value might be definitely ascertained.

RUBBER OF *RHYNCHODIA WALLICHII*, FROM BURMA.

This sample of rubber, prepared from *Rhynchodia Wallichii*, in Shewegyin, Tenasserim, Burma, was forwarded to the Imperial Institute for chemical examination and commercial valuation by the Reporter on Economic Products in January, 1904.

Several notices have recently appeared regarding the rubber-yielding properties of this plant, which is reported to be fairly common in the Pegu Division, and the rubber obtained from it has been described as of good quality.

The sample received for examination consisted of an irregular cake weighing 48 grams, which was slightly mouldy on the surface. The rubber was dark brown throughout, and contained a small amount of vegetable matter. Its physical properties were very satisfactory, it being quite free from stickiness and exhibiting good elasticity and tenacity.

The rubber had the following composition:—

	Sample as received. Per cent.	Calculated for dry material. Per cent.
Moisture	2·8	—
Caoutchouc	86·5	89·0
Resin	6·5	6·7
Dirt	4·2	4·3
Ash (included in dirt)	0·48	0·51

These results show that this specimen of the rubber of *Rhynchodia Wallichii* is of good quality, as the dry material contains 89 per cent. of true caoutchouc and only 6·7 per cent. of resin. It may be noted that a small amount, about 1·5 per cent. of the caoutchouc, was insoluble in the usual solvents.

The rubber was submitted to brokers for commercial valuation, and they reported that at the present time consignments of similar quality would sell readily in the London market at about 3*s.* 6*d.* per lb. This valuation, it must be noted, is based upon the high prices which are at present ruling in the rubber market, Para rubber being 4*s.* 8*d.* per lb. on the day upon which the valuation was obtained (May 20th, 1904), so that the price mentioned will represent rather more than the normal value of the rubber. There is no doubt, however, that the rubber of *Rhynchodia Wallichii*, if of similar quality to the present sample, would always sell readily and command a good price in the market. The plant is reported to be common in certain districts of Burma, and it therefore appears to be worthy of attention as a possible source of rubber.

RUBBER OF *CHONEMORPHA MACROPHYLLA* FROM BURMA.

This sample of the rubber of *Chonemorpha macrophylla* was prepared by the Conservator of Forests in Tenasserim, Burma, and was forwarded to the Imperial Institute for examination and valuation by the Reporter on Economic Products in February, 1904. The Forest Officer reports that the plant is not uncommon in the Tenasserim Division, but is being rapidly exterminated.

Rubber Chonemorpha macrophylla from Burma.

The sample consisted of a small conical piece of rubber weighing 14 grams, which was dark brown externally but almost white and slightly moist within. The rubber was rather sticky, but exhibited fairly good elasticity and tenacity.

The analysis furnished the following results:—

	Sample as received. Per cent.	Calculated for dry material. Per cent.
Moisture	8·0	—
Caoutchouc	55·2	60·0
Resin	34·6	37·6
Dirt and insoluble matter	2·2	2·4
Ash (included in dirt)	0·97	1·05

The rubber, therefore, contains a large amount of resin, over 37 per cent. in the dry material, and it is consequently of inferior quality. No definite conclusions regarding the quality and value of the rubber can be drawn, however, from the results of the examination of such a small sample as that submitted in the present case, and it would be desirable to collect and forward a much larger quantity for further investigation. A larger sample would be more representative of the average quality of the rubber, and could be submitted to brokers for commercial valuation, for which purpose the present specimen was too small.

Chonemorpha macrophylla has been known for many years as a rubber-yielding plant, and some information regarding it has been recorded. It has been recommended in certain quarters as suitable for cultivation, but from the experiences at Buitenzorg, where there is a plantation of the vines, this would appear to be doubtful, as the plant is stated to interfere with the development of the tree upon which it grows, and its increase in thickness is slow. It appears to be agreed, however, that the rubber which it furnishes is of good quality, but the collection is stated to be difficult, owing to the rapidity with which the latex coagulates in the cuts. Some information upon these points regarding the plants indigenous in Burma would be of interest.

"PONTIANAC" FROM THE PATIALA STATE.

This material was forwarded to the Imperial Institute on behalf of the Patiala Durbar, by Mr. T. H. Biddulph, Accountant-General, on deputation to the Patiala State, in December, 1903, with the request that a report upon its composition and commercial uses should be furnished. It was stated that the product is obtained from the forests of Patiala, but no information was supplied regarding the botanical source or method of preparation. The sample received for examination consisted of ten blocks, each measuring 6 ins. by 3 ins. by 2¼ ins., the total weight of which was about 7 kilograms. The blocks were light yellowish-brown externally, but were a uniform creamy-white within; most of them had fragments of paper adhering to the surface. The material showed a somewhat laminated structure, the outer layers being rather brittle, and although hard in the mass small pieces softened and could be moulded in the fingers; it was moist and had a slightly sour odour. In appearance and general properties the material was practically identical with commercial "Pontianac," a product obtained in the East Indies from *Dyera costulata* and other trees.

The chemical examination of the Patiala product conducted in the Scientific and Technical Department of the Imperial Institute gave the following results:—

	Sample as received. Per cent.	Calculated for dry material. Per cent.
Moisture	54·5 ...	—
Resin	36·6 ...	80·4
Caoutchouc	7·6 ...	16·7
Dirt and insoluble matter	1·3 ...	2·9
Ash (included in dirt)	0·94 ...	2·06

The material melted when heated at 100° C. and after removal of the moisture it solidified to a hard brown resinous mass. The isolated caoutchouc exhibited little elasticity but fair tenacity.

The analysis shows that in chemical composition, as well as in appearance and properties, this material from Patiala corresponds closely with "Pontianac," which, when dry, usually contains about 15 per cent. of rubber-like substance, and there is no doubt that it would be readily accepted as "Pontianac" in the market. "Pontianac" is largely employed in the United States at the present time as an ingredient in the mixtures used for the manufacture of low-grade rubber goods and recently the material has been strongly recommended as

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deserving more extensive use in this country also. Some particulars regarding the production and utilisation of “Pontianac” were given in a number of the *Bulletin of the Imperial Institute* (Vol. 1; p. 65).

The material from Patiala was submitted for valuation to brokers, who describe it as fairly dry “Pontianac” of the usual quality. From its appearance they consider that consignments represented by the sample would probably realise about 20*l.* per ton in the London market at the present time.

There is little doubt, therefore, that the material could be sold as “Pontianac” either in this country or in the United States, and, if it can be obtained in large quantities in Patiala, it would be desirable to forward a trial consignment of at least a ton to the London market, so that its value could be definitely ascertained.

MANGROVE BARKS, AND LEATHER TANNED WITH THESE BARKS, FROM PEMBA AND ZANZIBAR.

In a preliminary report on a sample of “msinzi” bark from the Island of Pemba, made by the Imperial Institute to the Foreign Office in March, 1903, it was suggested that it would be desirable to have a large consignment of this bark sent to the Imperial Institute, in order that tanning trials might be made with it on a commercial scale.

In response to this suggestion the materials which form the subject of the present report were received at the Imperial Institute through the Foreign Office in July, 1903, together with reports from H.M. Consul at Zanzibar, and from the Director of Agriculture to the Zanzibar Government, giving certain information regarding the production and botanical origin of these barks.

The mangrove bark imported into Zanzibar is stated to come principally from Wasin, Mombasa, Lamu, Tanga, and the coast towns. It is said to be procured from two different trees, “msinzi” (*Rhizophora mucronata*) and “mwi.” The barks from both these trees are reported to be equally valuable and are frequently mixed together. The “msinzi” tree grows in Zanzibar and Pemba, but attains no great size in these islands, and for that reason recourse is usually had to the mainland for supplies of the bark.

The cost of collection and transport to Zanzibar is stated to be about 15 rupees per ton, and the price in the Zanzibar market varies from 16 to 20 rupees per ton. At Marseilles the bark is said to be sold at from 3*l.* to 4*l.* per ton as a tanning material.

with barks, Pemba bar.

In addition to the samples of "msinzi" bark from Zanzibar there were also forwarded for examination samples of the mangrove barks "mkomafi" and "magomi" from Pemba, together with specimens of leather tanned by the natives with these barks. The letter accompanying these samples states that the "mkomafi" bark is obtained from the "msinzi" or "mtonga" tree, and the "magomi" bark from the "mkandaa" tree.

DESCRIPTION OF THE SAMPLES OF BARK.

A. "*Msinzi bark*" *from Zanzibar.*

This sample weighed about 60 lbs., and consisted of pieces of bark about half an inch in thickness, covered on the external surface with a rough brown scale. When cut transversely the bark was of dark reddish-brown colour, marked by numerous small round white spots.

B. "*Magomi bark*" *from Pemba.*

This material, which was stated to have been obtained from the "mkandaa" tree, closely resembled specimen A in appearance, but was somewhat darker in colour, and was free from the rough external coating. The sample was contained in two bags holding respectively 25 and 60 lbs. of bark. Specimens A and B closely resembled the sample of "msinzi" bark previously examined.

C. "*Mkomafi bark*" *from Pemba.*

This material was stated to have been derived from the "msinzi" or "mtonga" tree. It consisted of long curled strips of a thin brown bark, quite different in appearance from samples A and B. The outer surface was covered with a very thin scaly coating of a light brown colour. The cross section of the bark was free from the round, white spots characteristic of the "magomi" and Zanzibar "msinzi" barks.

There appears to be some confusion with regard to the vernacular naming of these barks Thus the bark called "mkomafi" in the letter accompanying the present samples should, if obtained from the "msinzi" tree of Pemba, be identical with the "msinzi" bark from Pemba forwarded to the Imperial Institute in 1901, and already reported on. It is, however, quite different in appearance from that material, which more closely resembles the "msinzi" bark from Zanzibar, and the "magomi" bark from Pemba among the present samples.

CHEMICAL EXAMINATION.

Mangrov barks, an leather tanned w these bar from Pem and Zanzibar.

The samples of mangrove bark have been examined in the Scientific and Technical Department of the Imperial Institute, and have given the results tabulated below, to which are added for convenience of comparison the results obtained with the specimen of "msinzi" bark from Pemba previously examined. As the samples were received in a very moist condition, they were allowed to dry in the air before being analysed, and the results recorded below are, except where otherwise stated, calculated on the air-dried bark.

—	"Msinzi" from Pemba. 1901 specimen	"Msinzi" from Zanzibar. 1903 specimen.	"Magomi" from Pemba.	"Mkomafi" from Pemba.
Moisture	16·2	16·4	18·0	16·0
Total ash	—	5·65	7·39	7·51
Ash soluble in water...	1·55	1·5	1·9	traces
Total matter soluble in water ...	49 4	50·2	49·8	29 8
Tannin, calculated on air-dried material	34 3	35 8	32 8	23·2
Tannin calculated on material dried at 103°	41 3	42 8	40·0	27·6

The tannin contained in these barks dissolved with difficulty in cold water, but was readily soluble in water at from 70–80° C. The aqueous extracts had a deep reddish-brown colour. The ash was in all three cases greyish-white, and consisted principally of calcium carbonate with a little silica.

COMMERCIAL VALUATION.

As mangrove barks are at present principally employed for the manufacture of extracts to be used for tanning purposes, large samples of the three barks were submitted, together with a statement of the analytical results already recorded, to a firm of extract makers for technical trial. They reported that the "mkomafi" bark, containing only 23·2 per cent. of tannic acid, would be of little or no commercial value here, but that the "magomi" and "msinzi" barks would probably be worth from 3*l*. 10*s*. to 4*l*. per ton, c.i.f., Glasgow.

LEATHERS TANNED WITH "MKOMAFI" AND "MAGOMI" BARKS.

The specimens of leather forwarded from Pemba for examination were described as follows:—

A. "*A piece of goat's skin prepared with 'mkomafi.'*"

This specimen measured about one square foot. The skin from which it had been prepared had been insufficiently cleaned,

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and the leather consequently showed traces of hair, which had not been removed in the cleaning process. The colour of the leather was light brown, with a slight reddish tinge.

B. "*A piece of ox skin prepared with* '*mkomafi.*'"

This specimen resembled (*a*) in colour and in showing isolated patches of hair. The leather was stiff and harsh.

C. "*A piece of ox skin prepared with bark of* '*mkandaa*' ('*magomi*')."

This specimen was better cleaned than either of the samples (*a*) or (*b*), but it had a deep brownish-red colour. The external surface was less porous than those of the leathers tanned with "mkomafi."

Specimens of these leathers were submitted to a leather expert for commercial valuation He reported that they could only be regarded as low-grade leathers, suitable for the manufacture of cheap boots. They would compete principally with the lower grades of American and Australian leather, and would probably sell in sides or whole hides at about 9*d*. per lb. There appears to be a fair demand for low-grade leathers of this type, and it might possibly prove remunerative to export such leathers from Zanzibar to this country

LEMON-GRASS OIL FROM MONTSERRAT.

A specimen of lemon-grass oil was forwarded to the Imperial Institute in September, 1903, by the Hon F Watts, Government Analytical and Agricultural Chemist to the Leeward Islands, with the request that its commercial value might be ascertained.

In the letter accompanying the sample, analyses of this and other West Indian lemon-grass oils were given, and the characteristic partial solubility of these oils in alcohol was noted. No information was given, however, regarding the exact botanical origin of the Montserrat oil, and as a knowledge of this point is of some importance in placing such products on the market a request was made for a herbarium specimen of the plant from which the oil was distilled, in order that it might be identified; at the same time a larger sample of the oil was asked for. These supplementary materials were received in January, 1904.

Identification of the plant.

The herbarium specimen of the plant was submitted for examination to the Director of the Royal Gardens, Kew, who identified it as *Andropogon nardus*, L., var. *genuinus* Hack, which is commonly known as the true lemon-grass.

Chemical examination of the oil.

Lemon-grass oil from Montserr

The oil was examined in the Scientific and Technical Department of the Imperial Institute, and gave the following results:—

The specimen measured about eight fluid ounces, and consisted of a clear, limpid, yellow liquid, with a pleasant lemon-grass odour. It dissolved to the extent of about 97 per cent. in 70 per cent. alcohol, and on distillation about 25 per cent. of the oil was obtained between 180°–220° C., and 50 per cent., which was principally citral, between 220°–230° C.

The following table shows the analytical results obtained with the Montserrat oil both at the Imperial Institute and in the West Indies, and for convenience of comparison the corresponding figures for commercial lemon-grass oil distilled in India from *Andropogon citratus*.

	Montserrat Lemon-grass Oil.		East Indian Lemon-grass Oil.
	Imperial Institute Analysis.	Mr Watts' Analysis	
Specific gravity at 15°C.	0 906	0 886	0·899 to 0·903
Angle of rotation in 100 m m tube .	−0° 10′	−0° 12 6′	+1° 25′ to 3° 5′
Citral determined by the sodium bisulphite method	74 6 %	74·2 %	70 to 75 %

These results indicate that the Montserrat oil contains as large a proportion of the valuable constituent citral as the East Indian oil, and only differs from the latter product in being incompletely soluble in 70 per cent. alcohol.

Lemon-grass oil is now principally employed as a source of citral, and the commercial value of the oil depends principally upon the amount of this constituent contained in it.

Commercial valuation of the oil.

Specimens of the oil, accompanied by a statement of the results of its chemical examination, were submitted to dealers in essential oils both in this country and on the Continent for commercial valuation. The reports from these firms indicated that, although in some cases there was a tendency to quote a low price (4½*d.* per ounce) for this oil owing to its being incompletely soluble in alcohol, yet the general opinion appeared to be that, if placed regularly on the market in fair quantities, it would be worth from 5*d.* to 6*d.* per ounce, which is about the price of good quality East Indian oil at the present time.

These results indicate that Montserrat lemon-grass oil, in spite of its peculiar partial insolubility in alcohol, would probably find a ready sale at remunerative prices in this country and on the Continent.

FIBRES FROM SOUTHERN RHODESIA.

These samples of fibres were received at the Imperial Institute from the British South Africa Company in December, 1903. They were accompanied by a report from Mr. E. R. Sawer, of the Agricultural Department of Southern Rhodesia, containing some observations on Sisal hemp, banana and pineapple fibres, especially with respect to their cultivation in Rhodesia.

The samples have been examined by the Scientific and Technical Department of the Imperial Institute, and have also been submitted to leading firms of brokers for commercial valuation.

No. 1.—Sisal Hemp.

This sample was stated to have been derived from a species of *Agave.* It consisted of soft, fine fibre, of good colour, well cleaned, and fairly strong. Its average length of staple was 33 inches. The brokers reported that its character resembles that of Mauritius hemp rather than that of Sisal, and that it would be worth from 32*l.* to 34*l.* per ton.

Sisal hemp is chiefly produced in Yucatan (Mexico), and in the Bahamas. The output from Yucatan for the year ending 30th June, 1902, amounted to 564,308 bales, weighing 90,005 tons, and of the total value 2,624,038*l.*

The following table gives the area under cultivation in the Bahamas, and the amount of Sisal hemp exported therefrom during the years 1901–1902:—

	Area under cultivation.	Exported to the United Kingdom.		Exported to the United States.	
Year.	Acres.	lbs.	£	lbs.	£
1901	18,036	24,232	486	1,514,246	18,048
1902	18,773	8,814	92	2,336,497	37,482

No. 2.—Banana Fibre.

This sample was of a dull, pale brown colour, and had a staple of average length 27 inches. The brokers reported that it was a somewhat soft fibre, of fair strength, stronger and more even than is usually the case with banana fibre, and worth from 25*l.* to 26*l.* per ton. This sample was much superior to specimens of the fibre received from Sierra Leone, which were examined in the Scientific and Technical Department of the Imperial Institute and reported on in the *Bulletin of the Imperial Institute,* 1903, Vol. I., p. 21.

About fifty years ago the production of banana fibre was carried on in Jamaica on a considerable scale, but it seems that in recent years this industry has ceased to exist.

The amount of banana fibre imported into this country is very small, but the exact quantity cannot be ascertained, since

Fibres from Southern Rhodesia.

this fibre is not classed separately, but is included in the Customs' returns under the general heading of hemp.

No. 3.—"Indigenous Fibre."

This specimen was unprepared, short, and extremely brittle. The brokers reported that it was of no value in the London market.

No. 4.—Pineapple Fibre.

This sample consisted of very fine, white, well-cleaned fibre, of average length 11 inches. The brokers reported that it was strong, but very short ; if, however, the fibre could be obtained of greater length it would probably be worth from 30*l.* to 40*l.* per ton.

A specimen of pineapple fibre received from India has been examined in the Scientific and Technical Department of the Imperial Institute, and a report on its quality and commercial value is published in the volume of "Technical Reports and Scientific Papers issued by the Imperial Institute," p. 73.

Pineapple fibre has long been used in India and China for the manufacture of lines and thread, and as a substitute for silk, and a material for mixing with wool or cotton. Pineapples are grown extensively in Singapore, chiefly for their fruit, but also to some extent for their fibre, which is exported to China. In the Philippines, the fibre is employed for the manufacture of the fabrics termed "piña" and "rengue." It has not yet been produced in quantities sufficient to give it commercial importance.

No. 5.—Baobab Tree Fibre.

This sample consisted of the bark of the tree, and was in an unprepared state. The brokers reported that it was rough and coarse, but that the value of the softer inner bark would probably be from 4*l.* to 5*l.* per ton.

This fibre was at one time sold as a material for the manufacture of paper, but has not appeared on the London market for several years. The trade was never a large one, and the fibre invariably came from St. Paul de Loando, and perhaps some adjacent port in Portuguese West Africa, to either Liverpool or Hull. The fibre was held in some esteem by makers of strong, light-coloured wrapping papers, and about 20 years ago good parcels ranged in value from 8*l.* to 10*l.* per ton. The amount imported gradually decreased from 190 tons in 1887 to two tons in 1896.

From the foregoing report it will be seen that the sisal, banana and pineapple fibres are of considerable commercial value. The brokers express the opinion that these three fibres would sell freely in the London market if imported regularly in bulk.

SEEDS OF *JATROPHA CURCAS* ("PURGING NUT") FROM LAGOS.

This consignment of oil seeds was forwarded to the Imperial Institute from Lagos in October, 1903.

The seeds were identified at the Imperial Institute as those of *Jatropha Curcas*, the "physic-nut" tree. The latter is cultivated in the Portuguese Colonies for the sake of its seed which is exported to Lisbon and is there employed for the preparation of Curcas Oil.

The seeds have been submitted to chemical examination in the Scientific and Technical Department and have given the following results. The kernels constituted about 66 per cent. by weight of the whole seeds. On extracting the decorticated seeds with ether, they yielded 52 per cent. of an oil which had a yellow colour, a faint, peculiar odour, and a bland, nutty taste.

It furnished the following constants:—

Specific gravity at 15° C.	0·919
Free fatty acids—	
Acid value	4·47
Free acids (calculated as oleic acid) ..	2·25 %
Saponification value	204·0
Iodine value	99·1
Ester value	199·5
Neutral oil	97·75 %

Curcas oil has been examined previously by several observers whose results vary within the limits given in the following table:—

	Previous observations.	Results of analysis of present sample.
Specific gravity	0·919—0·925 ...	0·919
Free fatty acids (calculated as oleic acid)	0·36—11·8 % ...	2·25 %
Saponification value ...	192—210 ...	204·0
Iodine value	98—110 ...	99·1

This oil belongs to the class of semi-drying oils and is employed for the manufacture of soap and candles, and also as an illuminant and a lubricant, but is not well adapted for the last-mentioned purpose on account of its drying properties. It is a strong purgative, and in India is used medicinally.

Samples of the seed and the oil were submitted to brokers and experts who reported that the oil can be used for soap-making, but at the present time would not be worth more than 14*l.* to

Seeds Jatrop Curcas ("Pu Nut") Lagos.

15*l.* per ton. The cake left after the expression of the oil would be unsuitable as a cattle food owing to its purgative action, and could only be used as a manure, for which purpose it would be worth 2*l.* to 3*l.* per ton. The value of the seeds, therefore, would not be more than 4*l.* to 5*l.* per ton.

It is improbable that manufacturers in this country would care to turn their attention to this product, but a market might perhaps be found for it in Lisbon or Marseilles.

LIQUORICE ROOT FROM BERMUDA.

This sample of liquorice root was forwarded to the Imperial Institute in March, 1904, by the Colonial Secretary of Bermuda, with the request that the commercial value of the material might be ascertained. The sample was accompanied by a memorandum from the Superintendent of the Public Garden giving information regarding the conditions under which this material was produced in the Colony.

It was stated that the liquorice root was grown from a number of rhizomes of the liquorice plant imported from France in 1902, and that four pounds of these were planted in somewhat poor soil, and from this material 250 lbs. of the root were harvested.

The sample weighed about eight ounces, and consisted of about 12 pieces of root, varying from 12 to 18 inches in length, and from a quarter to half an inch in diameter. When broken the roots were fibrous and had the characteristic yellow colour of liquorice root. The taste was fairly sweet.

The roots had evidently not been thoroughly dried before export, and had become somewhat mouldy during the voyage to this country.

Commercial Valuation.

The liquorice root imported into this country is obtained chiefly from Syria and Southern Russia. The former variety is somewhat coarse, and is principally employed in the manufacture of cattle foods and veterinary medicine. The Caucasian root, which is much finer, is usually sold in a decorticated condition, and is used for the manufacture of medicinal preparations. The commercial value of the unpeeled Syrian root is at present 10*s.* per hundredweight, and of the peeled root 20*s.* per hundredweight, while the Caucasian variety, which is always imported in a decorticated state, is worth from 30*s.* to 40*s.* per hundredweight, according to its condition.

A specimen of the Bermuda root was submitted to a leading firm of wholesale druggists for commercial valuation; they

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reported that its appearance and sweetness were midway between those of the Syrian and Caucasian varieties, and that it would probably sell at prices intermediate to those quoted above for these kinds. They also stated that there is a considerable demand for liquorice root in this country, and they suggested that a trial shipment of 10 tons of the natural dried root, and 5 tons of the decorticated material, if this can be prepared in the Island, should be sent to this country (consigned to London, or if this course presents any difficulty, to Bristol), in order to introduce the Bermuda root into commerce.

CACAO, COTTON AND HONEY FROM TRINIDAD.

These samples of cacao, cotton and honey were forwarded to the Imperial Institute by the Governor of Trinidad, in March, 1904, with the request that they should be submitted to examination and valuation by the Scientific and Technical Department. The specimens had been prepared by Mr. J. H. Hart, Superintendent of the Royal Botanic Gardens, Trinidad.

Cacao.

Two samples of this product, labelled No. 1 and No. 2 respectively, were received for examination, and they are stated to have been grown and prepared at River Estate, Diego Martin. No. 1 was a "select" sample which had been valued locally at 14 dols. per 110 lb., and No. 2, described as "good ordinary," was priced at 13 dols. per 110 lb. in Trinidad. The specimens were considered to represent the finest types of Trinidad cacao, and had been very highly commended in the Island. It was, therefore, desired to submit them for valuation and criticism to English buyers.

The favourable opinion which had been expressed in Trinidad regarding these samples was fully confirmed by their appearance, particularly in the case of No. 1, which was a very fine specimen of cacao. Both varieties were submitted for valuation to leading brokers, who have furnished the following report.

No. 1.—This is described by the brokers as bold, selected cacao of good appearance, apparently well-cured and fermented.

Cacao, cotton and honey from Trinidad.

The sample is stated to compare very favourably with the finest specimens of cacao from the leading Trinidad estates. Its value in the London market at the present time is estimated at 75*s.* to 77*s.* per hundredweight in quantity, but for a few bags only, if every bean were as large as in the sample, possibly 100*s.* per hundredweight might be obtained. The brokers state that a small lot of fine Maracaibo cacao has just been sold at 110*s.* per hundredweight.

No. 2.—The brokers describe this as small, clean cacao, worth from 60*s.* to 63*s.* per hundredweight in London at the present time.

It is evident, therefore, that the cacao prepared at River Estate, Trinidad, is of very good quality, and that the "selected" sample compares very favourably with the highest qualities in the market.

Cotton.

The sample of cotton submitted was grown and ginned at the Experiment Station, St. Clair. It is known locally as "Creole" or native cotton, and is believed to be a short-stapled or "Upland" variety which has survived since the old cotton-planting days. This variety is stated to suit the Trinidad climate better than "Sea Island" cotton, and might, therefore repay cultivation if the product realises a fair price.

The cotton was a pale cream colour, well cleaned, rather rough to the touch, and fairly strong. The length of the staple was 1·2 to 1·4 inches, which is a little above the average (1·1 inch) for American "Upland" cotton.

The sample was submitted to a leading firm of cotton brokers, who reported that it was a well-prepared cotton, and would be valuable on account of the roughness of the staple, in which particular it resembles semi-rough Peruvian cotton. It is valued at 8½*d.* to 9*d.* per pound at the present time, when "middling" American is quoted at 7¾*d.* per pound.

Honey.

The honey forwarded for examination and valuation was produced by Italian bees at the Experiment Station during the season when the logwood trees were in flower. This honey is stated to be very highly esteemed in Trinidad, and it was desired to ascertain whether this opinion would be confirmed in this country.

The sample was a viscous liquid of sherry-brown colour, and was almost perfectly clear. It possessed an excellent flavour and aroma. On chemical examination in the Scientific and

Cacao, cotton and honey from Trinidad.

Technical Department of the Imperial Institute it furnished the following results:—

Moisture (110° C.)	16·5 per cent.
Reducing sugars (calculated as dextrose)	80·7 ,,
Non-reducing sugars (calculated as sucrose)	2·4 ,,
Mineral matter (ash)	0·24 ,,
Insoluble matter	Trace.
Specific gravity at 15·5° C.	1·429
Rotation of 10 per cent. solution in 20 cm. tube at 20° C.	—2·5°

The composition of honey is liable to considerable variation, but the above figures correspond generally with those furnished by the majority of samples of genuine honey, in which the moisture generally ranges from 17 to 20 per cent., the total dextrose from 70 to 80 per cent., the ash from 0·10 to 0·25 per cent. and the specific gravity from 1·415 to 1·429.

The brokers to whom the sample was submitted report that it is of fair colour, clear, and would be worth about 20*s.* per cwt. in the London market, at which price they anticipate there would be a fair demand. For comparison with this valuation the current London prices for other varieties of honey may be quoted:—

Chilian	18*s.* to 30*s.* per cwt.
Californian	20*s.* to 40*s.* ,,
Jamaican	16*s.* to 27*s.* ,,

II.—GENERAL NOTICES RESPECTING ECONOMIC PRODUCTS AND THEIR DEVELOPMENT.

THE PRINCIPAL PETROLEUM RESOURCES OF THE BRITISH EMPIRE.†

Part III.—THE WEST INDIES.

Petroleum and allied substances are met with in several of the islands of the Antilles, including Cuba, San Domingo, Barbados, and Trinidad, as well as on the mainland in Venezuela, in the neighbourhood of the last-mentioned island.

I.—TRINIDAD.

*Geological relations.**

The most important deposits of these minerals in British territory are in the island of Trinidad, where they are met with both in the older Parian (neocomian) and newer Parian (tertiary) strata.

The older Parian is mainly developed in a strip running from east to west across the middle of the island from Point à Pierre to Mount Harris and Carata Hill. In this area bituminous substances, sometimes semi-solid, but more often liquid, ooze from the rocks at the foot of the hills, especially at certain points on the upper waters of the river Guaracare.

The bituminous and petroleum products of the newer Parian are much more extensive and important.

The Naparima marl occurs a little above the base of this group and is probably of miocene age. It consists largely of oceanic deposits. It extends from San Fernando and the river Cipero eastward by way of Savanna Grande, Dunmore Hill and Monkeytown to the neighbourhood of Point Mayaro, and is in places very rich in asphalt. The mineral is sometimes distributed through the rock and colours it so strongly that it appears to be a solid mass of bitumen, although it is, in fact, a shelly marl. Elsewhere the bitumen exudes from the joints which are lined with a coating of the same substance.

The Naparima marl is overlaid to the south by the Moruga or arenaceous series, which may be provisionally classed as pliocene. It occupies the greater part of the south of the island and consists mainly of thick beds of loose sand, but calcareous shale and lignitic beds are met with, and there is a considerable amount of bituminous material. This is stated to be confined to certain strata which appear to have originally

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† *Part I. of this article dealing with Canada appeared in the Imperial Institute Bulletin*, 1903, *Vol. I., p.* 188, *and Part II., dealing with India, in Vol. II.*, 1904, *p.* 97.

* *See G. P. Wall and J. G. Sawkins' Report on the Geology of Trinidad. London*, 1860.

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contained a large proportion of leaves and stems of plants and other vegetable débris, from which it is believed by some authorities to be derived. On the other hand, in the Naparima marl the evidence points to an origin from decomposed animal matter. The possibility that the bitumen was in some cases at least, not formed in the strata in which it now occurs, but came from underlying beds, must not be ignored. Being of a plastic or viscous nature, it tends to segregate into the various separation planes and hollows of the rocks, and is ultimately forced upwards through joints or crevices by the weight of the superincumbent beds and the pressure of the confined gases. On reaching the surface it spreads out, and slowly parting with its gaseous and fluid constituents, becomes a solid or semi-solid mass.

General characters and distribution.

Asphalt.—The commonest form of bitumen in the Island of Trinidad is asphaltum, known locally as pitch. It is brownish-black in colour, dull in lustre, and has usually an even fracture. It contains a large percentage of earthy matter and decayed vegetable products, some of which are derived from plants growing on its surface. When first raised it contains a considerable amount of water, and is then plastic rather than viscous. It can be squeezed into any shape, but is not adhesive and may be cut like cheese. It is therefore sometimes referred to as cheese-pitch. In this state it is a deep brown. It soon dries without any application of heat, if the atmosphere is not too moist, and becomes darker in colour and harder, but still retains some degree of viscosity. At the same time sulphates of the alkalis and alkaline earths separate out and tend to re-absorb a certain amount of moisture if the air be damp.

Asphalt is found in and near the pitch lake close to the village of La Brea (which signifies pitch in Spanish), on the north coast of the south-western promontory of the island. It also occurs at Oropuche (near La Brea), San Fernando, Moruga and Guayaguayareall, like La Brea, in the Moruga beds; also in the neighbourhood of Monkeytown, in the Naparima beds, and that of the river Guaracare, in the older Parian.

Sometimes, as for instance on the river Luna, near Moruga, and to the north of Mont l'Enfer, an area of one or more acres is occupied by a number of cones about two feet high, consisting of asphalt associated with earth. In other cases there is only one mass of much larger dimensions, but of similar character. These have frequently orifices in the centre by which the substance rises to the surface, in a liquid or highly plastic form. Very frequently the asphalt is only mixed with the soil in pieces or small blocks irregularly disseminated or passing down into the laminæ of the substrata.

Submarine asphalt occurs off Oropuche and Erin.

The principal petroleum resources of the British

Manjak.—The purer varieties of bitumen are known as glance-pitch, asphalt-glance, or manjak (formerly mountjack). They occur in two forms; one of these is hard and brittle with a conchoidal fracture and brilliant but intensely black lustre. The other resembles a good bituminous coal in appearance, being somewhat laminated and friable with an irregular fracture. It is black in colour and with the lustre of coal. If heated to 220° C. (430° F. per cent.) it becomes soft and gradually liquefies as the temperature increases, but has no definite melting point. On cooling it solidifies to a hard mass having the characters of the conchoidal variety.

Manjak occurs in much less amount than asphalt. In some cases it is supposed to have been formed directly from wood fragments, but this is very doubtful, it being more probable that the wood has been impregnated with the bitumen. Near San Fernando it occurs in veins traversing bituminous marl where it appears to have consolidated by the evaporation of the more volatile constituents.

The friable variety of manjak resembling coal is met with near the Guaracare river. In one locality to the north of that stream it is found traversing the soil in irregular veins. Important deposits have recently been discovered in the Marabella and Vistabella estates near the coast to the south of the same river. The conchoidal form is also found on the sea beach at Guapo and Guayaguayare, especially after stormy weather; which points to the occurrence of submarine deposits.

Liquid Asphalt and Petroleum.—Liquid asphalt is a dense black fluid with a powerful bituminous odour. It usually occurs mixed with water. After an exposure of some months its lighter constituents, which consist mainly of petroleum, evaporate, leaving a residue similar in character to conchoidal manjak. A liquid of similar character, but containing more petroleum, is known as asphaltic oil. A deep, brown petroleum containing but little solid bitumen is also widely distributed.

Liquid asphalt is mentioned as occurring near San Fernando in Guayaguayare Bay, and asphalt oil near Monkeytown and Oropuche (near La Brea).

Petroleum has been found in the river Guaracare; on the coast to the south-west of the pitch-lake, and as a submarine spring in the neighbouring sea. The most promising locality at present is in Guayaguayare Bay.

Composition and Commercial Aspects.

Asphalt.—Although the asphalt of Trinidad has been used for caulking ships almost from the time of the first discovery of the island by Europeans, and numerous experiments have been made with a view to its utilisation, it is comparatively

The principal petroleum resources of the British Empire.

recently that it has been exploited on a large scale for the preparation of road surfaces. Work was for a long time confined to the deposits near the shore at La Brea, but at present the greater part of the supply comes from the famous pitch lake about a mile inland.

The principal features of the asphalt deposits of this district have been recently described in the *Imperial Institute Bulletin*, 1903, vol. i. page 51. A valuable account will also be found in a paper on Trinidad pitch by S. F. Peckham and Laura A. Linton, in the *American Journal of Science*, series iv., vol. i., page 193, from which the following table giving the composition of commercial asphalt from different points in this locality is compiled.

Proximate analysis of asphalt from the La Brea district, exclusive of water, which may amount to as much as 30 per cent.:—

—	Bitumen = material soluble in chloroform.					Organic material insoluble in chloroform.	Inorganic material.	Total.
	Petrolene = material soluble in light petroleum.*	Asphaltene = material soluble in chloroform and not in petroleum spirit.			Total			
		Soluble in boiling spirits of turpentine	Insoluble in boiling spirits of turpentine	Total.				
Lake asphalt—								
North-east ...	36·499	13·411	4·025	17·436	53·935	10·371	35·675	99·981
Centre... ...	35·950	12·310	5·762	18·072	54·025	10·782	35·192	99·999
West	34·200	11·575	7·222	18·797	52·997	11·357	35·645	99·999
South-east ...	35·362	9·862	4·800	14·662	50·024	11·212	38·762	99·998
Land asphalt—								
Near lake ...	33·733	13·090	5·650	18·740	42·473	11·190	36·807	99·970
Near village ...	33·619	10·690	7·235	17·925	51·544	11·618	36·832	99·994

* *The solubility in light petroleum spirit is approximately the same as in acetone.*

Petrolene and asphaltene are not definite chemical compounds, but the latter is rather more oxidized than the former, which is essentially a mixture of petroleum oils.

The decomposition of asphalt is usually accompanied by an increase of the asphaltene at the expense of the petrolene. When the asphalt is melted or boiled as it is usually called, the material known as épurée is formed. This does not differ materially from crude asphalt except in the loss of water and a small amount of light petroleum. At the same time roots and other vegetable products are removed so that the proportion of insoluble organic material is diminished. In the process the specific gravity increase from about 1·30 to 1·44.

The principal petroleum resources of the British Empire.

The following are results of the distillation of dried commercial asphalt from La Brea:—

	Per cent.
Volatile hydrocarbons	51·81
Sulphur	10·00
Fixed carbon	9·72
Ash	28·30
Water	0·17

The ultimate analysis of the same material has been given as follows:—

	Per cent.
Carbon	80·32
Hydrogen	6·30
Nitrogen	0·50
Oxygen	1·40
Sulphur	11·48

This is exclusive of ash and presumably of non-bituminous organic material. The percentage of sulphur is very high; other analyses place it between two and three per cent.

Manjak.—Specimens from the Maravilla estate and the river Guaracare have been submitted to examination in the Scientific and Technical Department of the Imperial Institute (see *Bulletin*, 1903, vol. i., p. 180). The percentage of bitumen is very high, there being less than five per cent. of impurity, which consists of organic material insoluble in chloroform, and inorganic material. On the other hand it contains so little petrolene that it only liquefies at a high temperature, and a certain amount of petroleum "residuum," viz., heavy oils, would have to be added before it would be available for use in the arts.

Petroleum.—Numerous unsuccessful attempts were made in former years to exploit the petroleum industry of Trinidad. Already, in 1856, an American company had been established at La Brea for the distillation of illuminating and lubricating oils from the asphalt. In 1858 several thousand gallons were produced, but operations were soon suspended. In 1867 wells were sunk at different points. Those near San Fernando were unsuccessful, though a depth of 150 feet was reached. Oil was, however, found on the Aripero estate in Oropuche Bay and rose 180 feet in the pipes, but the enterprise was for some reason abandoned, and it is only recently that operations have again been renewed. More important, however, are the wells which have lately been sunk a mile and a half inland from the sea shore at Guayaguayare, to a depth of over 1,000 feet, with satisfactory results, well No. 2 yielding as much as 6,000 gallons a day, while a pit sunk close by to a depth of 18 feet, with a

The principal Petroleum resources of the British Empire.

cross section of 10 feet square, filled up, whenever it was emptied, in the course of a few days.

Samples of the oil from the well No. 1 and of that from a natural spring at some distance were submitted to the Scientific and Technical Department of the Imperial Institute for examination. The analyses and report, which will be found in the *Bulletin of the Imperial Institute*, Vol. I., p. 177, showed that they contained respectively 38 and 70 per cent. of kerosene (illuminating oil), and 43 and 27 per cent. of heavy lubricating oils. The well oil contained 11 per cent. of light petroleum. The heavy oil would be suitable for combining with the manjak from the deposits south of the river Guaracare in the manner already referred to as desirable.

The specific gravity of the well oil was 0·920, and its flash point 21·5° C. (70·7 F.). The specific gravity of the oil from the spring was 0·869 and its flash point 71·56° C. (160·8 F.). The specific gravity of other Trinidad oils varies from 0·930 (Aripero) to 0·971 (La Brea) and 0·980. The flash point varies from 15·5° C. (60° F.) (Aripero) and 24·5° C. (76° F.) (La Brea) to 165·5° C. (330° F.).

There appears to be every gradation between petroleum and asphalt, the bituminous material left on distillation gradually increasing from 2 per cent. in the petroleum to 20 per cent. in the semi-liquid asphalt.

The whole of the mineral organic products, including the coals, which have been examined at the Imperial Institute but do not come within the scope of the present article, require careful investigation, and there is every reason to believe that by the skilful treatment of the raw materials a number of valuable commercial products may be obtained.

No returns are available of the actual output of these minerals in Trinidad, but there are complete statistics of the exports, which in the case of asphalt correspond closely with the production.

In 1857 1,800 tons of asphalt were exported, and in the succeeding year the amount was nearly doubled. It then fetched, f.o.b., at La Brea, 10*s*. a ton. The export was mainly to France, the United States being the next largest customer. In 1873 the export had risen to 7,848 tons, in 1878 to 16,190 tons, in 1882 to 30,260 tons, in 1886 to 35,671 tons, in 1887 to 43,098 tons, and in 1888 to 52,017 tons.

The exports of asphalt and petroleum from 1889 to the last year for which statistics are available are given in the following table:—

Exports of Asphalt and Allied Products from Trinidad.

	Crude Asphalt.			Epurée.			Dry Asphalt.			Liquid Asphalt.					Total.	
	Tons.	Value £	Per ton.	Tons.	Value £	Per ton.	Tons.	Value £	Per ton.	Tons.	Gallons.	Value £	Per ton.	Per gall.		
1889	65,961			11,478												
1890	68,938			10,640												
1891	85,566			9,832												
1892	102,335			9,409												
1893	81,815			2,589												
1894	85,907			14,370												
1895	74,222			10,038							2,928					
1896	86,194			10,191							1,152					
1897	110,543	110,543	£1	14,129	28,258	£2									124,672	138,801
1898	86,574	86,574	£1	13,622	27,243	£2									100,196	113,817
1899	122,097	122,406	£1	14,483	29,609	£2 0 10	780	1.089	£1 7 11	21	4,270	49	£2 6 8	3½*d.*	137,381	153,153
1900	141,905	142,384	£1 0 1	16,847	33,695	£2				430*	86,000*	1,381	£3 4 3	4*d.*	159,182	177,460
1901–2	127,747	127,748	£1	15,648	31,296	£2	589	589	£1	102	20,492	169	£1 13 6	2*d.*	144,086	159,802
1902–3																170,563
1903–4																

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* The amount of liquid asphalt exported in 1900 is given as 2,052 gallons valued at £1,381; probably this is the number of barrels each of 42 gallons.

The principal Petroleum resources of the British Empire.

During the year 1902-3 566 tons of asphalt glance or manjak were also exported.

BARBADOS.

Geological Relations.

Bitumen and petroleum are associated in Barbados with the Scotland formation consisting for the most part of red, shaly, incoherent sandstones. Its exact age is uncertain, but it is believed to belong to the oligocene period. It is met with "below the cliff" in the parishes of St. Andrews, St. Joseph, and St. John on the north-east side of the island. In the latter parish they only occur in patches near the coast.

Distribution.

Manjak.—Asphalt does not appear to be present, but manjak, similar to the conchoïdal variety of Trinidad, has been found at many points, among which may be mentioned the following localities—near Groves to the south-east of Mount Hillaby; near Springfield to the west of Lloyd's Wells; on the coast near St. Margarets, Quinty and Consett Bay, and on the property of Codrington College. A seam of manjak traverses the grey limestone near the summit of Burnt Hill, and the mineral is met at other points in the neighbourhood. The hill owes its name to a fire which burnt for five years in an outcrop of manjak.

Petroleum.—Petroleum is found in the valleys of the streams that flow by Turner's Hall Wood, Haggats and Baxter. It is sometimes visible on the surface of the water both of the rivers and of the springs as at Mount All. It is also met with at Springfield and at Lloyd's Wells, close to the coast.

Natural gas consisting mainly of methane is evolved from the "boiling spring" in Turner's Hall Wood.

Analyses and Commercial aspects.

Manjak—The following are some analyses by distillation of the Barbados manjak. A is an analysis by Herepath, of Bristol, quoted by Sir Robert H. Schomburgh in 1847. B an analysis by P. P. Bedson, and C one by J. H. Pye, both in recent years:—

A.

Bitumen (resolvable by heat into tar and gas)	61·6
Coke	36·9
Ash	1·5

B.

Volatile matter	61·90
Fixed coke	36·12
Ash	1·58

C.

Volatile organic matter	70·85
Non-volatile organic matter	26·97
Ash	·18
Moisture	2 00

The manjak was found to be almost entirely soluble in chloroform, and consequently consisted of nearly pure bitumen. It was partially soluble in light petroleum, and therefore contains a proportion of petrolene. A sample examined at the Imperial Institute melted at 104° C. (327° F). It has accordingly a lower melting point than the Trinidad manjak, and the percentage of petrolene is probably higher.

An ultimate analysis gave the following result exclusive of ash:—

Carbon	81·18
Hydrogen	8·43
Oxygen	10·39

Corresponding roughly to 20 atoms of carbon, 25 of hydrogen, and two of oxygen. The proportion of the latter is much higher than would have been expected. The absence of sulphur is noteworthy.

Manjak was first worked in January, 1896, and the new industry has met with a considerable amount of success, but recently the export has diminished, though the price has advanced.

There were in 1901-2 nine mines in operation. Three of these belonged to one company which employed 70 to 80 labourers. Another mine afforded employment to only eight persons who were paid a shilling a day, the total production amounting to 200 tons per annum.

The manjak is mainly exported to the United States where it is employed in the manufacture of Brunswick black, and as an insulating material for electric cables.

Petroleum.—The petroleum from Barbados is black and tarry, or deep brown, from the presence of bitumen. The density ranges from 0·945 to 0·971, and the flash point from 116° C. (240° F.) to 149° C. (300° F.).

A sample with density 0·951 gave on distillation 94 per cent. of heavy oil and 6 per cent. of coke, but no light petroleum or kerosene.

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The petroleum industry was for a long time confined almost exclusively to Lloyd's oil wells in the parish of St. Joseph, which were originally 21 in number. They were 5 feet in diameter, 80 to 140 feet in depth, and lined with pine wood. The average yield of each well was from one to two barrels a day; one well yielded green oil.

In 1901-2 there were 19 wells in the entire island, 12 of these, which were from 4 to 6 inches in diameter and 60 to 1,000 feet in depth, were capable of yielding 1,400 gallons a week, but the total output was only about 7,200 gallons per annum. The petroleum, especially the green variety, was long employed as a medicament, both externally and internally, in Barbados and the adjoining islands. It is now used locally as a fuel and as a lubricant, and sells at from 2*d.* to 6*d.* per gallon.

Statistics.

The following table of exports of manjak and petroleum compiled from official returns. The values given are in some cases too low, for instance, the price of manjak delivered free on board in 1897 was 7*l.*, not 2*l.*

No returns are made of the output of the mines or wells.

EXPORTS OF MANJAK AND PETROLEUM FROM BARBADOS.

Year.	Manjak.				Petroleum.		
	Tons.	Value.	Price per Ton.		Amount.	Value.	Price per barrel.
		£	£	s.		£	£
1896	878	1,756	2	0	6 barrels	18	3
1897	1,880	3,760	2	0	—	—	—
1898	1,160	2,320	2	0	2 barrels	6	3
1899	1,026	4,617	4	10	52 "	156	3
1900	1,120	6,162	5	10	—	150	—
1901	1,044	9,394	9	0	—	—	—
1902	868	7,816	9	0	—	—	—
1903	651	6,508	10	0	—	—	—

NEW INDIAN COALFIELDS.

The current number of the *Records of the Geological Survey of India* contains reports on two new Indian coal-fields, which, though insignificant when compared with the great coal-fields of Bengal and the midlands of India, are of considerable local importance. The report by Mr. Simpson on the coal deposits of Isa Khel of the Salt range, Punjab, show that in this district there are several small areas containing coal-seams generally of small thickness and often of poor quality. Four areas are mapped out, and the following information is given regarding them.

At Kalabagh three seams of coal of Jurassic age occur varying in thickness from one foot to four feet. They are extremely variable and thin out rapidly towards the east. The coal is a black, shining lignite with a specific gravity of 1·57, due presumably to its containing much ash. It breaks with a semi-conchoidal fracture, burns with a smoky flame and unpleasant odour, and is liable to spontaneous combustion. The quantity available is estimated at 70,000 tons, and the present output is about 300 tons per day.

Six miles north of Kalabagh, Jurassic coal beds are again seen two miles north of Kuch. There are two coal seams, respectively 16 and 12 inches thick, separated by 15 feet of shale. Both seams are lenticular and of small extent. The total quantity available is estimated at 14,000 tons. The coal resembles that of Kalabagh, being a hard, black lignite. In the third area mentioned, between the Chichali Pass and Malla Khel, the coal is reported to be of no economic value.

Several outcrops of coal were found exposed on the banks of the Barochi stream and its various gorges. This coal is a hard lignite of good quality, occurring in seams of variable thickness and limited in extent. The average thickness appeared to be from two to three feet. The quantity available is not stated, but must necessarily be small.

An exhaustive series of analyses of these coals is given, but the results are somewhat misleading since although the proximate analyses are made on an air-dried sample, the evaporative power appears to have been determined on samples dried at 212° F., and consequently the latter figures appear abnormally high for lignite of the quality indicated by the proximate analyses. Analyses of a few of the typical coals are given in the following table:—

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Locality.	Depth from surface. Feet.	Thickness of seam. Feet.	Moisture per cent.	Volatile matter per cent.	Fixed carbon per cent.	Ash per cent.	Sulphur per cent.	Evaporative power on sample dried at 212° F. per cent.
Kalabagh	20	2·5	7·43	25·27	36·28	30 52	—	—
Kuch	7	1·33	10·19	22·74	46·12	18·60	2 35	9·68
Barochi Gorge ...	6	2·08	5·20	33·26	36·27	16·00	9·27	12·19
" ...	6·5	3·08	10·87	38·77	42·81	5·04	2·51	10·45
Charma Gorge ...	4	3·6	5·02	42·40	41·34	5·60	5·64	14·35
Kerai Gorge	7	5·5	7·52	35·43	43·00	9·72	4·33	11·68

It will be observed that all these coals contain unusually large quantities of sulphur, which would be an objectionable constituent. The second report by Mr. P. W. Bose describes a newly discovered coalfield in Assam, which, though of small extent, contains, like most other Assam fields, coal of good quality. Two seams were found outcropping at the foot of Dinghie Hill close to the head waters of the Um-Rileng river. Bore-holes have been put down in two localities in this area, one of which failed to strike coal, and the second at the time the report was written had not reached the coal level. From an examination of the outcrops and information derived from trenches the total area is estimated at 3,750,000 square feet, giving 470,000 tons of available coal. Analyses of coal from the two trenches gave the following results:—

	Trench No. 1. Per cent.		Trench No. 2. Per cent.
Moisture	16·02	...	17·36
Volatile matter ...	47·17	...	43·84
Fixed carbon ...	30·39	...	32·75
Ash	6·41	...	6·05

indicating that the material is of fairly good quality.

THE CULTIVATION OF THE PARA RUBBER TREE IN CEYLON.

The success which has attended the experimental cultivation of the Para rubber tree in Ceylon and the Straits Settlements has attracted the attention of planters in all tropical countries suitable for its growth, and at the present time numerous plantations of the trees are being established in different localities. A number of reports, dealing with the various questions involved in the cultivation of the trees and the preparation of the rubber, have been already published, and recently the methods actually in use at one of the most successful rubber plantations in Ceylon have been fully described in a series of articles in the "Indiarubber and Gutta Percha Trades Journal" (Vol. 27, pp. 471, 567, and Vol. 28, p. 37). A short summary of the information contained in these may be of service for comparison with previous descriptions.

It was formerly believed in Ceylon that the Para rubber tree (*Hevea brasiliensis*) would only flourish upon low-lying land up to an elevation of 500 feet, but this view was quite erroneous, and was not supported by the range of the tree in its natural habitat. Experiments have shown that in Ceylon the tree will thrive and furnish paying quantities of rubber when planted upon hill sides up to 2,700 feet, and it is still undecided whether its cultivation can be successfully undertaken at higher altitudes. It is stated that the tree grows most rapidly at elevations of about 500 feet, but for practical reasons an elevation of from 1,000 to 1,500 feet is preferred for plantations, as in the latter case the latex flows more freely, especially in the hot weather, whilst the yield of rubber is the same as at the lower altitude. The tree will grow apparently upon very poor soil, though the yield of rubber would probably not be very remunerative under such conditions, and plantations will, of course, always be established on fairly good soil, which should not be too stiff.

The trees are raised from seed, the soundness of which should be ascertained by breaking a number selected at random, as it is almost impossible to distinguish good from bad seed by appearance only. If the seeds are procured from a distance it is necessary that they should be carefully packed, as otherwise they are very liable to lose their vitality during transit. The method adopted on the estate in question is to wash the seeds in a solution of copper sulphate and then pack them in damp powdered charcoal, a process which has given very satisfactory results for journeys up to four weeks' duration.

The seeds are usually sown in nursery beds situated upon good land which is fairly level and has a supply of water conveniently at hand. The plot should be divided into beds about

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20 feet long and 4 feet wide, with a drain one foot wide and deep between. After the beds have been levelled the seeds are placed in the soil, being preferably laid upon their side, at a depth of about half an inch. It is customary to sow the seeds about 6 inches by 6 inches apart, but if plenty of land be available, this distance can be increased with advantage to one foot by one foot. The seeds are well watered twice daily, and germination soon occurs; subsequent growth is rapid, and in ten days the seedlings are above ground, whilst ten days later they are nearly 10 inches high. The average height of the plants when ten months old, if the seeds have been sown 6 inches by 6 inches apart, is stated to be 6 feet. The young plants require protection from the attacks of insects or animals, and the beds must be screened from direct sunlight by means of a good cover placed about 2 feet above the soil. At the end of a month the cover of the nursery is gradually taken off, and in two months' time it should be removed altogether, as the young plants will then grow better if exposed to the full sunshine. It is stated that the success of raising the plants from seed is dependent upon the care bestowed during the first ten days.

When the plants are about 5 or 6 feet high they are transferred to their permanent positions, previous to which the stem is usually cut off about 18 inches above the soil, and has no leaves up to that height at the time of planting. The young plants are placed in prepared holes filled with surface soil, great care being taken that the tap-root is put in straight, and the soil is pressed firmly against it. The ground should be kept clear of weeds and the young plants protected, if necessary, from animals until they are about 6 feet high, after which they will grow on without much further trouble.

Some planters prefer to sow the seed in the position which the tree is to occupy, and if this course is adopted, the procedure employed in the nursery must be followed in each individual case.

The distance at which the trees should be planted, in order to obtain the best results has given rise to considerable diversity of opinion, some authorities recommending close planting and others distant. From the results obtained in Ceylon it is suggested that the trees should be placed 15 feet by 15 feet apart, giving about 200 trees per acre. It is admitted that trees planted 30 feet by 30 feet apart grow much faster and bigger than when they are closer together, but in this case there are only about 50 trees per acre, and, as the yield of rubber per tree is not very much greater than from closer planted trees, the return per acre is considerably less. Trees planted 15 feet by 15 feet apart have given an average yield of 1 lb. of rubber per tree, whilst others planted 30 feet by

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30 feet apart have only averaged 1¼ lb. of rubber per tree, an increase insufficient to compensate for the great reduction in the number of trees. Distant planting is, therefore, only recommended when it is desired to grow some other product, such as cacao, in the shade furnished by the rubber trees.

The trees are tapped for the first time in their seventh year, at which age a large proportion should have attained the necessary size of at least 18 inches in circumference. In Ceylon the usual method of tapping is by a series of V-shaped incisions, a tin cup being fixed below each in order to collect the latex. Some planters make the first cuts about 6 feet from the ground and work downwards, but the method employed on this estate is to commence operations about 3 feet from the ground and on every second day to make two fresh cuts, one above and one below the previous ones. The incisions are placed in vertical rows down the trunk, about 1 inch apart, and each limb of the V is from 2½ to 3 inches in length. Usually four rows of incisions are made, each of which contains 60 distinct cuts, making a total of 240. The tapping process is thus spread over a period of about two months, and it is claimed that this method yields much more rubber than the older practice of making a larger number of incisions at once. After four or six months' time the trees are again tapped, the new incisions being made between the previous rows.

Tapping is only performed in the early morning, from 5.30 to 9 a.m., as it has been found that the yield of rubber obtained from a given number of incisions made in the evening is only about one-third of that furnished by the same number made in the morning. The coolies work in groups of three; the first makes the incision, the second affixes the tin cup, and the third pours a little water into each cup directly it is placed in position. The tin cup has a fairly sharp edge which is simply pressed into the bark just below the incision and this attachment is sufficiently firm to prevent the cup from falling, even when full of latex. The object of placing a little water in each cup is to retard the coagulation of the latex until the total yield can be treated in the factory. The coolies usually finish placing the tins by about 8.30 or 9 a.m., they then collect the latex in pails and deliver it in the factory by about 11 a.m. They afterwards return to the trees and collect the "scrap" rubber which has coagulated in the incisions made two days previously. The opinion is expressed, however, that it might be better to leave this rubber in the wounds as it seals the cut surfaces and helps them to heal quickly. The loss would not be very great, as the amount of "scrap" rubber obtained is only 132 lb. for every 1,000 lb. of good rubber prepared from the latex.

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The following particulars are furnished regarding the size of the trees and the yield of rubber. The average size of a seven-year-old tree is about 50 feet in height, with a circumference of from 20 to 22 inches 3 feet above the ground, whilst trees 13 years old have a circumference, measured as above, of from 45 to 53 inches. The results of tapping experiments show that a tree will give about 8 ozs. of rubber in its seventh year and 10 ozs. in the next; trees from nine to 11 years old will, if carefully tapped, furnish 1½ lb. per tree during the year, and there is no appreciable average increase on this yield from trees 11 to 13 years' old, as the latter give from 1½ to 2 lbs. of rubber per tree. The following examples are given of actual results obtained on tapping nine-year-old trees:

Two hundred and ten trees, growing at an elevation of about 500 feet, were tapped in January and February, and gave 150 lbs. of dry rubber; the same trees tapped again during August and September yielded 207 lbs. of dry rubber, making a total of 357 lbs. during the year, or 1·7 lb. of dry rubber per tree.

In another case 237 trees at an elevation of about 1,000 feet gave 162 lbs. of rubber when tapped in April and May; in November and December a further quantity of 230 lbs. was obtained from them, giving a total yield of 392 lbs., or 1·65 lb. of dry rubber per tree.

The process employed for the preparation of the rubber from the latex is extremely simple, and may be briefly described. The latex is first strained through a sieve with fine mesh, in order to free it from all extraneous solid matter, and is collected in circular enamelled basins about 10 inches in diameter and 2 inches deep. The latex is allowed to stand without any addition until the next morning, by which time it has coagulated spontaneously, and the cake of rubber is found floating on the liquid. The cake is then lifted out and placed upon a sloping table to drain, the removal of the water being facilitated by pressure, first with the hands and finally with a wooden roller. In using the roller it is recommended to work from the centre to the edge all round before going right over as otherwise the cake is liable to pucker. The liquid which is expressed from the cakes is collected and allowed to stand for some time, when a further quantity of rubber separates, amounting to 1 or 1½ lb. for every 30 lbs. of cake rubber.

After the water has been thoroughly removed from the cakes they are placed upon sloping tables for about 48 hours, and while still soft they are usually branded with the name of the estate. The cakes are then transferred to wire trays for 24 hours, and are finally hung up on wires in a darkened room and allowed to dry until they are quite clear. The time required

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for drying naturally depends upon the thickness of the cakes or "biscuits," as they are technically called. "Biscuits" four to the lb. require over three months to dry perfectly clear, if artificial drying is not employed, whereas if made eight to the lb. the operation is complete in six weeks. By the adoption of artificial means of drying, such as the use of fans and stoves, the time occupied could of course be greatly reduced and the dry rubber placed upon the market at a much earlier date. If the "biscuits" become mildewed when hanging on the wires, as frequently happens during wet weather, they are thoroughly washed just before packing and then put back on the wires for three days to dry again. For export the biscuits are usually packed in small boxes holding about 400 cakes or 50 lbs. of dry rubber. The quality of the rubber produced upon this estate is indicated by the fact that the average price obtained for all the rubber exported during 1903 was 4*s.* 4½*d.* per lb.

Some information regarding the cost of establishing rubber plantations and of the size and equipment of a factory for preparing the rubber are also given in the articles. It is estimated that to open up an estate of 200 acres in Ceylon with rubber trees, and to maintain it to the end of the sixth year, will cost Rs. 63,990 or about 4,200*l.* Of this amount Rs. 28.990 is allotted for the first year's charges, whilst the subsequent upkeep is estimated at Rs. 7,000 per annum. From the writer's experience he concludes that a factory 72 feet by 24 feet with two floors would be sufficiently large to deal with six tons of rubber per month, provided hot air be used for drying, and rough plans are given for a building suitable for the purpose.

COTTON CULTIVATION IN THE UNITED STATES.

The attention of the United States Department of Agriculture has been directed recently to a number of questions relating to cotton cultivation, and an account of the results which have been obtained is given in the Annual Reports for 1903. The most important problems dealt with are the production of long-stapled "upland" cotton, the acclimatisation of Egyptian cotton, and the prevention of injury to the crops by disease or insect pests.

The quantity of long-stapled cotton produced in the United States is at present somewhat limited, whilst the demand is steadily increasing. Attempts are being made, therefore, to establish new races of long-stapled "upland" cotton which

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will give yields comparable with those of ordinary "upland" cotton and be thoroughly adapted for growth in the "upland" cotton regions. The long-stapled "upland" cottons which are now cultivated possess various defects. Their fibre is somewhat weak and their seeds are downy; on this account they cannot be treated satisfactorily with a roller gin, and if a saw gin is employed the fibre is liable to be injured and broken. It is hoped that by hybridising the fine long-stapled "Sea Island" cotton which has smooth, black seeds, with the short-stapled "upland" variety, which bears large bolls and downy seeds, new varieties may be obtained which will possess large bolls, smooth seeds and long, strong fibre. In the course of experiments undertaken with this object, no less than 40,000 hybrids have been produced from which certain types have been selected. These selected plants are being carefully cultivated with the view of securing fixed types which, it is hoped, will yield the desired results and furnish a fibre of from 1¼ to 1¾ inches in length.

Experiments are also being conducted with the object of improving the strength and length of staple of the best long-stapled "upland" cottons already existing, and it is considered that much may be accomplished in this direction by careful methods of seed selection.

Considerable attention is being devoted to the cultivation of Egyptian cotton in the United States. The demand for this material is constantly increasing, whilst the area under cultivation in Egypt is incapable of much extension. The value of the annual imports of Egyptian cotton into the United States amounts to about 1,600,000*l*. It has been found that when the Egyptian cotton plant is first introduced into American soil it gives a poor yield, and the fibre tends to lose certain of its characteristics. Experiments are in progress to obtain by careful selection varieties which will prove adapted to the new conditions. One variety which has been cultivated for three years in South Carolina is very promising and is being grown on a considerable area. Another variety, obtained by hybridisation of "Sea Island" cotton with "Mitafifi," has been submitted to selection experiments, and during 1902-3 gave an excellent yield of fibre of fine quality but of rather variable length. Samples of these products have been reported in many instances to be equal to the best cotton grown in Egypt. It is confidently expected that varieties will be secured ultimately which will be thoroughly suited to cultivation under American conditions.

The possibility of producing cotton plants capable of resisting disease has been made a subject of special study, and important results have been obtained especially in the case

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of "wilt" or "black-heart" disease. Certain forms of "Sea Island" cotton have been produced by a process of careful selection and have been tested on a large scale by cultivation on infected land. It has been found that these new strains are quite resistant to the "wilt-disease" and yield crops of superior quality. Work is also being carried on with the object of improving the "wilt-resisting" forms of "upland" cotton. This disease has been found to be more prevalent among "upland" cotton than was formerly supposed.

An investigation has been made of the "cotton root-rot," a disease of parasitic origin, and it is believed that the fungus causing it has now been identified for the first time. Experiments are being conducted by methods of selection with a view to the production of forms of cotton resistant to this disease.

The cotton crop of the United States is seriously menaced by the continued spread of the "boll-weevil" (*Anthonomus grandis*, Boh.), a small, greyish insect of rather less than a quarter of an inch in length which punctures the buds or bolls and lays its eggs in them. The larvæ are produced within the bolls and feed upon their tissues. The development of the bolls is thus impaired, and they become dwarfed or stunted. The insect caused considerable damage to the cotton crop in Mexico in 1862, and first appeared in Texas in 1894. The life history and habits of this weevil have been thoroughly studied, and efforts are being made to discover suitable means of checking its ravages. The possibility of controlling the pest by means of parasites has received special attention, and an expert has paid a visit to Mexico, where a Government Commission appointed to investigate the weevil problem has been studying the propagation of a mite (*Pediculoides ventricosus*) which has been found to destroy the larvæ of the insect. Cultures of this parasite have been taken to Texas, and the work is being continued, but the results obtained hitherto seem to indicate that the climatic conditions in Texas will not permit of success.

Experiments have proved that cotton can be grown with profit even in districts infested by the boll-weevil, if seed selection, early planting and thorough cultivation are adopted.

Owing to the importance of this subject, reference may be made to the recent discovery of an ant which preys upon the boll-weevil. An article on this subject written by Mr. O. F. Cook, of the United States Department of Agriculture, and dated May 11th, 1904, has been published in *Science*.

During a visit to Guatemala in the year 1902 it was noticed that a small Indian cotton plant cultivated by the natives was not attacked by the weevils, whilst the insects were very common in the flowers of a tree-cotton growing spontaneously at a short distance from the plantation.

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More recently, owing to the increasing ravages of the boll-weevil in Texas, the existence of this cotton plant, which is not attacked by the boll-weevil, was recalled, and it was thought desirable to ascertain, if possible, whether the plant possesses any quality enabling it to resist the pest, or to what causes its immunity is due. A careful search showed that the boll-weevil is present, but is kept in check by a large, reddish-brown ant, which is attracted to the plant by the food which it secures from the extra-floral nectaries. The ant seizes the weevil in its mandibles and inserts its sting at the point unprotected by the beetle's armour. The weevil is killed immediately, and is carried away in the jaws of its captor. The manner in which the destruction of the pest is accomplished seems to show that the ant is by structure and instinct specially equipped for the purpose. The insect appears to be hardy and able to survive a long, dry season and cold weather in Guatemala.

It is hoped that it may be possible to introduce this ant successfully into the cotton plantations of the United States.

COTTON CULTIVATION IN THE DUTCH INDIES.

Cotton appears to be widely cultivated in the Dutch Indies, but definite information as to the area devoted to the industry and the amount of cotton produced is not readily obtainable. It is stated that in 1898 the exports from Java amounted to 12,810,000 lb.

Cotton growing was commenced in the Dutch Indies early in the nineteenth century. The first consignment of cotton which was sent to Europe was said to be much shorter and coarser than American cotton, and, in consequence of this report, attempts were made to cultivate better varieties. In Java, experiments were carried out with *Gossypium vitifolium*, but in 1839 the crops were destroyed by caterpillars and the trials were discontinued. Some years later further attempts were made, and a bale of cotton which was sent to Holland in 1845 was reported to be of better quality; unfortunately, however, the cost of production rendered the trial unremunerative. Many other experiments have been carried out from time to time with exotic varieties of cotton, but usually without much success.

In spite of all these failures Teysmann and De Vries have expressed the opinion that cotton cultivation in these colonies might acquire considerable importance, and further trials have been conducted in recent years. An account of these experiments has been given by Dr. W. R. Tromp de Haas in "Teysmania," 1903.

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The results obtained in Java and Madura show that cotton cultivation can be carried on successfully in the northern and eastern districts, but that in the western districts the industry is liable to failure on account of the irregularity of the climate. The hopes raised by Teysmann with regard to cotton cultivation, and especially as to the introduction of foreign varieties, have not been realised, and, in spite of efforts to develop the industry, the importance of cotton growing in the Dutch Indies is diminishing year by year.

The risks incurred in cultivating either good exotic or even indigenous varieties of cotton deter the native planter from taking up the industry. In many districts the natives prefer the cultivation of other plants, such as tobacco or the sugar-cane, which demand less care and labour, and give a larger profit.

A comparison of the yield of cotton in Java with that obtained in the United States shows at once the difficulty experienced in carrying on the industry in a remunerative manner, for whilst in America 340 lb. of cleaned cotton are obtained per bouw (approximately 1·75 acres), the yield in the Dutch Indies, under favourable conditions, only amounts to 200 lb. per bouw, and the cotton produced is of inferior quality.

THE STRUCTURE AND PROPERTIES OF "MERCERISED" COTTON.

The changes produced in the properties and structure of cotton fibre by the action of alkali in the process of "mercerising" are of considerable interest, both from the practical and from the scientific standpoint. The influence of alkalis and other chemical reagents on the tensile strength and tinctorial properties of cotton yarns has already been investigated by Messrs. Hubner and Pope, and a short account of their conclusions has been given in the *Imperial Institute Bulletin*, 1903, vol. I., pp. 43–44. These authors have continued their work and embodied their later results in a paper published in the *Journal of the Society of Chemical Industry*, 1904, vol. 23, pp. 404–411.

In order to ascertain the effect of alkali on the tinctorial properties of cotton fibre, hanks of yarn were steeped in cold solutions of caustic soda of varying concentration (from 0·4 to 36·5 per cent. of sodium hydroxide), and were afterwards washed with cold water and dyed with benzopurpurin 4B. It was found that the affinity of cotton for direct dyestuffs was considerably increased by treatment with soda solution of

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0·4 to 8·0 per cent. strength, and that the amount of the increase was roughly proportional to the strength of the solution employed. In the case of solutions containing from 8·0 to 9·5 per cent. of soda the increase in the concentration of the alkali causes a greater increase in the affinity for the colour than does a corresponding increase of concentration in weaker solutions. This effect is more marked in solutions of 9·5 to 11·4 per cent. strength, and still more at concentrations of 11·4 to 13·5 per cent. Beyond this point the effect of an increase in the strength of the soda in increasing the affinity of the cotton for colour is less, so that raising the strength of the soda from 13·5 to 17·7 per cent. has only about the same effect as an increase from 11.4 to 12·6 per cent., or from 12·6 to 13·5 per cent. Above a concentration of 20·1 per cent. an increase in the strength has only a slight influence on the shade of colour produced on dyeing, and above a concentration of 32 per cent. any further increase in strength is accompanied by a diminution in the affinity of the fibre for dyestuffs; thus yarn treated with 32 per cent. soda solution dyes much more strongly than that treated with 36·5 per cent., and in the latter case the shade produced is only of the depth obtained with soda of 15·3 per cent. strength.

Experiments were made to test the influence of the temperature of the alkali solution on the affinity of cotton for dyes. A remarkable result was obtained; it was found that whilst hot soda solution of 8·7 per cent. strength causes the production of a deeper shade in dyeing than 4·4 per cent. soda applied cold, yet soda of 13·5 per cent. strength used hot gives less depth of colour than cold soda of a concentration of 8·7 per cent.

Since cotton yarn is usually boiled with soda of 0·5 to 1 per cent. strength as a preliminary to bleaching, a series of trials was carried out to ascertain the effect of this treatment on the dyeing properties of the material. The results showed that the custom of boiling the yarn with dilute soda causes no increase in the affinity of the cotton for substantive colouring matters, although when the yarn is treated with cold soda of the same concentration a deeper colour is produced on dyeing.

Many chemical reagents effect an increase in the affinity of cotton for direct dye-stuffs. Experiments were conducted in which hanks of bleached cotton were treated with solutions of barium mercuric iodide, potassium iodide, hydrochloric acid, zinc chloride and nitric acid, and were afterwards washed, dried and transferred to the dyeing bath. In each case the affinity for the colour was found to increase with the concentration of the solution, but no reversal of this effect was observed like that caused by soda of certain strengths.

A series of tests was made to determine the extent to which cotton yarn is shrunk by treatment with soda solution of

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different concentrations. The results showed that very dilute soda, even of 0·5 per cent. strength, causes a greater shrinkage of the yarn than pure water does, and that as the strength of the soda is increased the amount of shrinkage increases uniformly up to a concentration of 8·7 per cent., whilst above this point the extent of the shrinkage increases much more rapidly, the greatest effect being obtained with soda of 20 per cent. strength; as the concentration is further increased, the amount of shrinkage gradually diminishes until a strength of 36·5 per cent. is reached. During the subsequent washing of yarn which has been treated with 36·5 per cent. soda, the alkali, of course, undergoes gradual dilution, in consequence of which shrinkage occurs owing to the action of the dilute soda on the fibre. This peculiarity is of some practical importance, for if the yarn is treated with soda of greater strength than 30 per cent, allowance must be made for the further shrinkage during the washing in order to meet a tendency to tearing or ripping caused by the strain exerted on the mercerising frame.

The microscopic examination of the changes induced in cotton by mercerisation was made with the aid of crossed Nicol prisms, between which was inserted a mica plate of such thickness as to increase the retardation of the light passing through the preparation by one-eighth of a wave-length. The raw cotton fibre appears as a flattened ribbon, the edges of which are somewhat thickened and turned up. The internal canal is clearly visible in polarised light, and is seen to extend through the whole length of the fibre. The cotton fibre is naturally twisted or creased; the twist is sometimes in one direction and sometimes in the other, several changes in the direction occurring in the length of a single fibre. This variation in the direction of the twist is of great importance in connection with the production of lustre during mercerisation.

The behaviour of cotton fibre when treated with soda solution of different concentrations was studied. The most important phenomena observed are epitomised in the following table:—

Strength of soda solution.	
0—6·5 %	No apparent effect.
7—8 "	Incomplete uncoiling of the fibre for about a second.
8·7 "	Untwisting, at first rapid and afterwards slow.
11·4 "	Rapid and slow uncoiling take place simultaneonsly lasting about 5 seconds.
15·3 "	Untwisting followed by swelling.
17·7 "	Untwisting and swelling proceed together.
27—36·5 "	Swelling precedes untwisting.

The concentration of 17·7 per cent. is the lowest at which mercerisation for practical purposes can be effected. It is evident, therefore, that for the production of the lustre on cotton, the untwisting of the fibre must take place either after the swelling has occurred or simultaneously with it. In con-

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firmation of this conclusion, it has been found that under the action of hot soda solution (which does not produce a marked mercerising effect) the untwisting of the fibre precedes the swelling.

The lustre of mercerised yarn was formerly attributed to the shrinkage and swelling brought about by the action of the strong soda solution, whilst a third factor, the untwisting of the fibre, was entirely overlooked. The results of an investigation of the action of a number of reagents on stretched cotton yarn have proved that all three of these factors are essential to the production of any considerable lustre. The reagents employed were a mixture of water-glass and caustic soda, a mixture of glycerine and caustic soda, sulphuric acid, solution of zinc chloride, syrupy phosphoric acid, nitric acid, hydrochloric acid, and solutions of sodium sulphide, potassium iodide, potassium mercuric iodide and barium mercuric iodide. Of these reagents, those which caused the production of the best lustre were caustic soda, soda with water-glass, soda with glycerine, and nitric acid; all these caused rapid untwisting, strong swelling and considerable shrinkage. Sodium sulphide and hydrochloric acid effected rapid untwisting of the fibre, but only slight swelling and shrinkage, and produced little gloss on the yarn. Barium mercuric iodide caused considerable swelling and shrinkage, but did not effect the untwisting of the fibre, and consequently gave rise to but slight lustre. Zinc chloride, potassium iodide and potassium mercuric iodide caused no untwisting and but slight swelling and shrinkage, and hence produced very little lustre.

A study has been made of the mechanical effect which gives rise to the lustrous appearance of yarn mercerised under tension. If a raw cotton fibre, the two ends of which are fixed to a microscope slide by means of wax, is treated with soda solution of 30 per cent. strength, it first straightens itself and then swells, becoming rounded and gelatinous ; after it has reached this stage, the untwisting begins. Since the fibre is fixed at each end it follows that as one part gives up its natural twist, another part becomes twisted. This action goes on repeatedly until finally the original twist of the fibre is replaced by a new kind of twist. The fibre now has the appearance of a gelatinous, straight rod on which spiral windings are visible; after being washed and dried it still retains this form. By this process the creased band which constituted the raw fibre is converted into a straight rod of nearly circular cross-section which bears on its surface a series of spiral elevations. The surfaces of the fibre and the ridges are quite smooth ; the latter reflect the light in the same way as the turns in a polished corkscrew, and it is to the presence of these ridges that the increased lustre of cotton yarn mercerised in the stretched condition is due.

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THE PAPER TREE OF TONKIN.

The tree known in Tonkin under the name of "cây gió" is cultivated by the natives for the sake of its bark, which is employed in the manufacture of paper. This plant has been identified as *Daphne involucrata*, Wall., of the natural order *Thymelæaceæ*. It has long been used in India for paper-making, the bark being employed in admixture with that of the allied species, *Daphne cannabina*, the so-called Nepal paper plant. In Annam, an extensive area is devoted to its cultivation amounting, in the Province of Hung-hoa alone, to about 670 acres. An account of the cultivation of the tree and the method of utilising its bark has been contributed recently to the "Revue des Cultures Coloniales," 1904, vol. 14, pp. 175-182 and 271-273.

The plant grows best in an alluvial soil which is rich in humus and can be easily irrigated, and it readily accommodates itself to the changes of temperature of the Tonkin climate.

The following method of cultivation is practised by the natives. The seed is sown in February or March according to the temperature. If the heat tends to injure the seedlings they are shaded with screens of palm-leaves. In the same period of the following year the young trees are transplanted at intervals of 30 to 40 inches in plantations which usually have an area of ¾ to 1½ acres and rarely extend to 2½ acres. The branches are cut in August or September of the third year, before the plant has flowered; they have a diameter varying from about one-half to an inch and a length of 1½ to 2 yards. The number of branches borne by one tree is usually from five to 12, but sometimes amounts to as many as 20. After the branches have been gathered the leaves are removed and the bark is stripped off by hand. The product thus obtained has the appearance of soft, flexible, fibrous ribbons; it is dried thoroughly by exposure to the sun.

A tree of the age of three years yields, on the average, about 12 oz. of fresh bark or 4½ oz. of the dry material. Assuming the presence of 1,400 plants per acre, the yield of dry bark would amount to approximately 400 lb. per acre. This quantity is the maximum obtainable by the cultural methods at present employed. The natives usually make four cuttings at regular intervals of three years; the second crop is of the best quality. At the end of 12 years the plant is exhausted and is then considered to furnish too small a yield to warrant its further cultivation. The bark in its raw state sells at different prices according to its quality; the first quality realises about 24*s*. per cwt., whilst the lowest quality is sold at about half this price.

The Paper Tree of Tonkin.

The total quantity of the dry bark produced annually in Hung-hoa amounts to about 120 tons. About 24 to 30 tons is used in the village of Phi-dinh for the manufacture of paper; the remainder is distributed among the following villages:—Vu-yên, 35 tons; Yên-luong, 15 tons; Van-phu, 35 tons; Thach-dé, 5 tons.

It is considered that the yield of fibre might be greatly increased by the adoption of improved methods of cultivation. Before transplanting the young trees, the soil should be well prepared and freely manured. The plants should be selected rigorously, and only those should be transplanted which bear well-formed stems and are provided with numerous roots. During the first year, the plantation should be weeded two or three times. In the second and third years occasional ploughing is required in order to clear the ground of adventitious plants and to allow of the admission of air to the lower layers of the soil; this treatment is particularly necessary if the soil contains much clay.

It is estimated that under systematic cultivation each plant would yield about 9 oz. of dry bark or double the amount produced by the native methods. Since an acre would probably produce 4,000 plants under these conditions, the total yield of dry bark would amount to about 1 ton per acre of the average value of 16*l.*

In the village of Phi-dinh, Hung-hoa Province, the manufacture of paper is carried on by the following method. The bark of "cây gió" is immersed in water for 48 hours and is afterwards soaked in weak milk of lime for the same length of time. Whilst still impregnated with lime it is submitted to the action of steam for 24 hours, and is afterwards washed and cleaned, and reduced to a pulp by means of a pestle and mortar. The pulp is again washed and then transferred to a rectangular wooden vessel filled with water to which a gummy substance has been added derived from a tree known as "cây mo." The paper manufacturers purchase the wood of this tree from the native foresters who collect it in the mountains. The wood is converted into chips or shavings which are steeped in water for 12 hours. The gummy water so obtained is poured into the wooden vessel in which the pulp is afterwards placed. About 1 lb. of "cây mo" shavings is required for 30 lbs. of the "cây gió" bark. The pulp is withdrawn, shaken, and spread out in thin layers. The sheets thus formed are placed in a pile which is pressed in order to remove the excess of water. Finally, the sheets are separated from one another and dried in the sun. The paper obtained in this way is always more or less bibulous. The process of sizing paper, with the object of rendering it impermeable, is quite unknown to the natives.

The Paper Tree of Tonkin.

In the village of Lang-buoi, near Hanoi, paper is manufactured in a somewhat different manner. The bark is macerated first in water and afterwards in lime water. It is then heated with water in a hermetically sealed vessel for three or four days. The two layers of which the bark is composed are next separated by means of a knife ; the outer layer is brown, whilst the inner layer is yellowish in colour and more fibrous. The former serves for the manufacture of paper of inferior quality, the latter being reserved for a finer, whiter and less bibulous paper. Each portion is converted into a pulp by means of a pestle and mortar, and the pulp is transferred to large baskets and carefully washed with water. The product is put into wooden troughs provided with water which contains a certain amount of the gummy substance derived from "cây mo." The sheets of paper are then made in the manner already described.

There is another plant used in Tonkin for paper-making which bears the native name of "cây cánh," or the wild "cây gió." This is a small bush not exceeding 36 to 40 inches in height. The branches attain a maximum thickness of about half an inch; the bark contains a fibrous tissue, the fineness of which contributes to the production of pulp of very good quality. The plant has not been completely identified, but is recognised as a member of the Natural Order, *Thymelœaceœ.* It grows in poor, dry, stony soil, and is able to bear the greatest summer heat without injury. "Cây cánh" has always been neglected on account of the small proportion of bark that it yields, and experiment has shown that notwithstanding the superiority of the paper made from this material the regular cultivation of the species would not prove remunerative. The pulp, however, might be utilised in combination with ordinary pulp to improve the quality of the paper.

The paper mulberry (*Broussonetia papyrifera*), a plant indigenous to China, Siam, Polynesian Islands and Burma, is frequently met with in Tonkin by the roadside, but its cultivation has never been adopted by the natives. This tree bears a greyish-brown bark which is greatly esteemed in Japan as a paper stock, is used in Burma for the manufacture of *papier maché* and is employed in the Sandwich Islands and Hawaii for making native cloth.

THE TEA PRODUCTION OF THE BRITISH EMPIRE.

The introduction of tea into Europe dates from the early part of the 17th century ; its cultivation and use had then been long established in China and Japan, and for the next 200 years these were practically the only countries from which it was obtained Early in the 19th century, however, European nations began to experiment on the possibilities of growing tea in their eastern possessions, and these efforts have proved so successful that the output of tea from India and Ceylon now rivals that of the Chinese Empire. In the year 1826 the Dutch succeeded in establishing tea gardens in Java, and the years 1836 to 1840 saw the commencement of the export trade in Indian-grown tea. In the year 1873 Ceylon began to export tea, and the industry has flourished so well there that the export thence at the present time does not fall much behind the total production of tea in India. An account of the history and present state of tea cultivation within the British Empire has been recently published by Mr. A. G. Stanton in the "Journal of the Society of Arts" for June 3, 1904, and from it most of the following points of interest have been summarised.

As regards its cultivation the tea plant requires both sunshine and rainfall in liberal proportions ; the latter amounts to 100 inches or more per annum in most tea districts, and in some parts even exceeds 200 inches. The best soil is a rich loam, but it also grows where there is a free subsoil, as this permits the penetration of the long tap root of the bush. The aim of the planter is to produce as much leaf of good quality as possible ; the flower is of no use for making tea, and is only allowed to develop when seed is desired. The leaf bud and two, or perhaps three, leaves are plucked from the fine shoots ; if more leaves are plucked the tea becomes coarser and of lower quality. The plucking is made at intervals of eight or nine days or so by women and children, and they bring the leaves in baskets to the factory.

On the Indian plantations machinery is employed in the various processes of manufacture, and thus the large amount of handling that Chinese tea meets with in the course of its preparation is avoided. The first stage in the manufacture is the withering process ; in this the leaves are laid out thinly on trays or sheets until the rigidity of the leaf-cell disappears and the leaf becomes soft and easily rolled. When the withering is satisfactorily advanced, the time required varying with the state of the weather, the leaf undergoes the second process, being rolled by machinery to break up the softened leaf-cells and cause the sap to exude. The third process, which is one of fermentation or oxidation, follows ; the rolled leaf is allowed to ferment until it assumes a bright cop-

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pery tint. The fourth operation, the firing, is then performed by placing the leaves in a drying apparatus and heating them to a fairly high temperature; this stops the fermentation and the colour of the leaf is changed to black. The tea is then separated into different sizes by means of sieves, to suit the requirements of different markets, and is packed in chests for sale.

Green tea is obtained by a variation in the process of manufacture ; the withering and fermenting stages are omitted and the leaf is steamed, rolled and immediately fired, and thus the green colour of the chlorophyll is preserved.

Some idea of the magnitude of the industry may be obtained from the fact that in the year 1902 the total amount exported from the tea-producing countries of the world amounted to about 615 million lb. The actual amount produced is of course far larger, as the quantity consumed by the 400 million inhabitants of China is unknown and must be very considerable since tea is used throughout the Chinese Empire. Of this export Great Britain consumed 255 million lb., and the British colonies 60 million lb. ; thus, rather more than one-half of it went to the British Empire. As consumers of tea, the inhabitants of Australasia take the lead using about 7 lb. per head per annum, those of Great Britain come next with 6 lb., followed by the Canadians with 4 lb. Excluding China and Japan, no other nation approaches these figures; Holland taking only 1½ lb., Russia about 1¼ lb., and the United States about 1 lb.

The growth of the industry in India is shown by the following table (Stanton, *Journal Society Arts*, 1904, vol. 52, p. 608).

APPROXIMATE ACREAGE UNDER TEA CULTIVATION IN INDIA WITH THE ANNUAL YIELD AND THE AVERAGE PRICE OBTAINED IN THE LONDON MARKET.

Year.	Area.	Yield.	Average Price.
	Acres.	Lb.	*s.* *d.*
1881	221,671	46,371,622	1 5
1891	362,487	123,867,902	0 10¾
1898	501,680	157,475,400	0 8·30
1899	515,658	181,797,455	0 8·75
1900	522,487	197,460,664	0 7·74
1901	524,767	191,302,773	0 7·50
1902	525,252	188,589,261	0 7·85

Of the total area under tea in India in 1902 by far the larger portion, namely, 340,000 acres was situated in Assam, followed by 135,000 acres in Bengal and 50,000 acres distributed over Madras, the Punjab, Burma, the United Provinces, Travancore and Cochin.

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The remarkable rise of the Ceylon tea industry dates from the ruin of the coffee plantations by the attacks of a fungus *Hemileia vastatrix*; the planters in consequence turned their attention to tea growing, and have been most successful in their efforts, as is shown in the following table (Stanton *loc. cit.*).

ACREAGE UNDER TEA CULTIVATION IN CEYLON, WITH THE QUANTITY EXPORTED AND THE AVERAGE PRICE OBTAINED IN THE LONDON MARKET.

Year.	Area.	Export.	Approximate Average Price.
	Acres.	Lb.	*d.*
1871	Nil.	Nil.	—
1881	13,500	348,157	11¾
1891	250,000	67,718,372	10
1898	370,000	110,769,071	7·76
1899	385,000	129,894,156	7·96
1900	392,000	148,431,639	7·20
1901	388,000	146,299,018	6·86
1902	385,000	148,991,241	6·81
1903	386,000	151,120,009	7·52

In the English market, Indian tea met with more and more favour owing to its greater strength and flavour as compared with that from China, and the large quantities both of Indian and Ceylon tea which were taken by England caused a very considerable decrease in the consumption of Chinese tea. This is apparent in the following table (Stanton, *loc. cit.*) which also shows how greatly tea-drinking has increased in the last forty years.

ANNUAL CONSUMPTION OF TEA IN THE UNITED KINGDOM, SHOWING THE QUANTITIES AND PERCENTAGES DERIVED FROM INDIA, CEYLON, CHINA, &C.; AND THE AVERAGE ANNUAL CONSUMPTION OF TEA PER HEAD OF POPULATION.

Year.	China, &c.		India.		Ceylon.		Total.	Per head of population
	lb.	Per cent. of Total.	lb.	Per cent. of Total.	lb.	Per cent. of Total.	lb.	lb.
1866	97,681,000	96	4,584,000	4	—	—	102,265,000	3·42
1871	109,445,000	89	13,956,000	11	—	—	123,401,000	3·92
1881	111,715,000	70	48,336,000	30	—	—	160,051,000	4·58
1891	52,287,304	26	98,941,931	49	51,227,602	25	202,456,837	5·36
1898	19,512,009	8	133,430,351	57	82,471,745	35	235,414,105	5·83
1899	23,403,946	10	134,018,921	55	85,137,946	35	242,560,813	5·95
1900	19,297,051	8	138,025,026	55	92,470,009	37	249,792,086	6·07
1901	17,087,828	7	147,959,733	58	90,825,521	35	255,873,082	6·16
1902	20,171,477	8	148,727,837	58	85,540,878	34	254,440,192	6·06
1903	26,092,339	10	150,780,655	59	78,492,959	31	255,365,953	6·03

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When commencing the industry the planters of India and Ceylon naturally sent their teas to the London market, but in time it was found that notwithstanding the diminution in the import from China, there was still an excessive supply, and that the price was falling. Efforts were, therefore, made to open up new markets outside the United Kingdom, and the planters both in India and Ceylon agreed to voluntary levies and later to taxes collected by their respective Governments to be devoted to promoting the use of their teas in other countries. The success that attended this policy is shown by the following table (Stanton, *loc. cit.*):—

QUANTITIES OF INDIAN AND CEYLON TEA TAKEN BY COUNTRIES OTHER THAN THE UNITED KINGDOM.

Year.	Indian.	Ceylon.	Total.
	lb.	lb.	lb.
1890	9,430,942	4,570,190	14,001,132
1895	16,815,323	19,923,803	36,739,126
1900	33,442,970	49,259,693	82,702,663
1901	36,080,151	58,797,549	94,877,700
1902	42,361,366	64,374,989	106,736,355
1903	47,588,221	71,592,169	119,180,390

Among the countries contributing to make up the above totals, Australasia, North America and Russia with Germany appear as the largest consumers. Australasia in 1890 imported about 26 million lb. from China, but Chinese tea has now been largely displaced by British-grown tea, which now amounts to about 80 per cent. of the whole consumed. In the United States of America green tea is most in favour, and to meet this taste the manufacture of this form of tea has been stimulated in Ceylon by means of a bounty. In the year 1903 this bounty was paid on 11 million lb. In 1901 India adopted the same plan, and in 1903 the bounty was paid on nearly 2 million lb. The introduction of British teas into Russia was difficult at first, but has now met with great success, something like 35 million lb. having been taken in 1903. The amount taken by Turkey with Persia is not inconsiderable, amounting in 1903 to 8½ million lb.

Although India and Ceylon are by far the most important tea-growing countries within the British Empire, yet there are several other Colonies where tea cultivation has been tried, and in Natal the industry has reached some magnitude. The following table shows the growth of the industry in that Colony (Stanton, *loc. cit.*, p. 606).

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AREA OF LAND UNDER TEA CULTIVATION AND QUANTITY PRODUCED IN NATAL.

Year.	Area.	Production.
	Acres.	Lb.
1880	8	Not shown.
1883	149	"
1888	801	133,200
1893	1,883	576,420
1898	2,667	1,037,589
1900	4,162	1,679,600
1901	4,107	1,720,150
1902	3,542	1,796,230

In this Colony the industry is protected by a duty of 4*d*. per lb. on imported tea. Natal tea also finds a free market in Cape Colony, the Transvaal, and in the Orange River Colony, consequently very little of it is exported from South Africa, as remunerative markets are close at hand.

As regards the smaller trials of tea-growing, the following particulars are recorded:—236 acres in Fiji in 1901; 145 acres in Mauritius in 1901; 75 acres in Jamaica in 1903; 35,000 lb. in the Straits Settlements in 1902; trials have also been made in Borneo.

Besides a suitable soil and climate, a supply of cheap labour is a most important element for success, and the labour difficulty is especially pronounced in Assam, and is becoming serious in other Indian tea districts and in Ceylon. The remuneration of the planter is not only dependent on the above factors, but also on the fluctuations in the value of silver, the duties imposed by England and other countries and on the effects of the tendency to over-production.

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WHEAT EXPERIMENTS IN CANADA.

In no branch of industry has the remarkable progress of Canada been more marked than in that of agriculture. The area of land under crops is rapidly increasing, and the exports of farm produce have nearly doubled during the last seven years.

The seventeenth "Annual Report of the Director of Experimental Farms" (Ottawa, 1904), contains an account of the work done during 1903, and affords striking proof of the valuable nature of the experiments carried out at the Government Experimental Farms.

Among the most important of the experiments were those initiated with the object of obtaining a variety of wheat possessing earlier ripening qualities than the sorts commonly grown in Canada. The necessity for experiments in this direction arose from the losses sustained by farmers in the North-West Territories during the last 20 years, occasioned by the repeated occurrence of early frosts in these districts. Among the spring wheats held in high regard in the Colony, and especially in the North-West, is the variety known as "Red Fife." This wheat is remarkable for its productiveness, for its high quality, and for its power of adaptation to varying conditions of soil and climate. It originated as a variation on the fields of Mr. David Fife, Ontario, about 60 years ago, and up to the present shows no signs of deterioration. It was taken from Ontario to Manitoba and the North-West Territories, where it now stands probably higher in the estimation of millers for its flour-making properties than any other known variety. While the "Red Fife" has so many points of excellence, it is open to one objection, viz., lateness of ripening. This drawback can, of course, be disregarded in wheat-growing districts warmer than the North-West Territories.

The experimental work has been carried out along two distinct lines. In the first place, foreign varieties of wheat have been imported, and grown for several years at all the experimental farms, the time of ripening and weight of crop in each case being carefully compared with those of "Red Fife." The wheats tested came from all the chief wheat-growing countries of the world; some were obtained from the colder districts of Northern Russia and other parts of north Europe, some from different altitudes in the Himalayas, and others from the United States, Australia, and Japan.

The results of the experiments showed that, on the whole, the Russian and Indian wheats ripened earlier than the Canadian "Red Fife." On the other hand, their quality was often inferior, and the crops raised were frequently so small, that,

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from a financial point of view, the cultivation of these varieties was impossible. The most satisfactory grain was the Ladoga, from Northern Russia. It ripened fully a week earlier than the "Red Fife," and gave a fairly heavy crop; the chief objection was the slightly yellow colour of the flour. The wheats from the United States, Australia, and other sources proved to be as late as, or even later than, the "Red Fife," and were of inferior quality.

The net result of the first series of experiments is therefore, that, up to the present, it has been impossible to find a foreign earlier ripening wheat which possesses, when grown in Canada, the productiveness and high quality of "Red Fife."

The second method by which the desired end has been sought, is the cross-breeding of wheats with the object of combining the good qualities of two or more varieties. The experiments were begun in 1888, and since that time several hundred new sorts have been produced and tested. A considerable number of crosses were effected between the "Russian Ladoga" and the "Red Fife," and the most promising of the progeny were multiplied until plots of considerable size could be grown. These latter were subjected to rigid inspection from year to year, and the less desirable plants were promptly destroyed in order to keep the number of varieties under trial within reasonable bounds.

Among the most successful of the many new varieties obtained are those known as "Preston" and "Stanley." The "Preston" is a bearded sort, the "Stanley" is beardless. Taking the average yield obtained on the plots on all the experimental farms for a period of nine years, the "Preston" has given a crop of 34 bushels, 41 lbs. per acre, while the "Red Fife" has yielded 33 bushels, 7 lbs., a difference of 1 bushel, 34 lbs. per acre in favour of the "Preston." The "Preston" has also ripened uniformly earlier, the gain in time averaging from four to six days. The "Stanley" is a twin wheat with the "Preston," and its origin is one of considerable interest. The plants grown from the first cross-bred kernel produced, in the following season, heads which were uniformly bearded; but when the seed from the latter was sown some of the plants produced bearded heads, and others beardless, the two varieties being distinguished as the "Preston" and "Stanley" respectively. Subsequently the two varieties were bred to type by discarding all the variations arising, until the forms became fixed. "Stanley" during a nine years' test has given an average crop of 32 bushels, 2 lbs. per acre, which is 1 bushel, 5 lbs. less than "Red Fife." In early ripening, this variety is about the same as the twin "Preston."

A wheat much grown in some parts of Manitoba and the

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North-West Territories is the "White Fife." It affords a slightly larger yield than "Red Fife," but in quality is somewhat inferior. This wheat was also crossed with the "Russian Ladoga," and the best results obtained are known as "Huron" and "Percy." "Huron" is bearded, and during experiments extending over nine years, has yielded 4 lb. per acre in excess of "Red Fife." Its time of ripening, moreover, is four to five days earlier than that of the latter variety. "Percy" yields a smaller crop than Red Fife, but also ripens five days earlier. Another cross was obtained between an Indian and a Russian variety. The former, known as "Gehun," was procured from an elevation of 11,000 feet in the Himalayas, and "Onega," the Russian variety, was brought from Archangel, one of the most northerly wheat-growing districts in Russia. The most valuable of the progeny is the "Early Riga," which, although slightly inferior to "Red Fife" in point of productiveness, nevertheless ripens no less than nine days before that variety, and is one of the earliest ripening wheats known.

Having thus obtained several promising varieties as the result of cross-breeding, the next question considered was the quality of the new wheats from the point of view of the miller. To gain information on this point, three sets of wheats were put up; each consisted of two samples of "Red Fife" of the best quality, and two each of "Preston," "Stanley," and "Percy." The two samples of each variety were obtained from different parts of the country, viz., Ottawa, Ontario, and Indian Head, North-West Territories. The sets were distributed to three experts for examination, two being sent to practical millers, and the third to the Government chemist.

The results were very satisfactory. The reports by the experts show that in colour, strength, appearance and milling structure the two cross-bred wheats, "Percy" and "Stanley" are fully equal to "Red Fife." The "Preston" stands equal to "Red Fife" in appearance and milling structure, but falls slightly below it in point of strength. When put to the test of valuation on the London Corn Exchange, "Percy," "Stanley," and "Red Fife" were quoted as being worth 34*s*. 3*d*. for 496 lbs., and "Preston" as worth 34*s*. Samples of other wheats, including "White Fife," "Laurel," and several hybrids, among which was the "Early Riga," were also submitted for examination. Of these, the "Early Riga" easily took the first place, its quality being superior even to that of "Red Fife." If, in conjunction with this fact, the early ripening qualities of this hybrid (nine days before "Red Fife") be taken into account, it will be seen that in "Early Riga" the Canadian farmer possesses a wheat which promises to be valuable. The report of the chemist is also one of considerable interest. It was found that,

Wheat Experiments in Canada.

judging of excellence from the albuminoid and gluten content, all the wheats were of the same general character, and were, in some particulars, practically identical. Differences, however, were found to exist, and the advantage, though small, lay with "Percy "Red Fife" and "Stanley" were classed as equal, being closely followed by "Preston."

Summing up, the value of experimental cross-breeding of wheats seems conclusively proved. Within a comparatively short time several new varieties have been obtained, which, up to the present, have given very favourable results. Such varieties are of the greatest value, not only on account of their permitting of an extension northwards of the already enormous wheat-growing areas of the Colony, but also from the point of view of the farmer with relatively limited resources. It frequently happens that such a wheat-grower is under the necessity of cutting part of his crop before it is quite ripe, in order to avoid "shelling" of the wheat before the harvest is complete. To such a settler the advantage of sowing part of his land with an early ripening variety is obvious.

NOTICES OF SOME RECENT UNOFFICIAL PUBLICATIONS.

(*All these books have been added to the Imperial Institute Library.*)

A TEXT-BOOK OF COMMERCIAL GEOGRAPHY. By C. A. Adams, B.A., F.A.G.S. Pp. xvi. + 506. (New York and London: 1904, D. Appleton & Co.)

This volume, which is one of the series of Twentieth Century Text-books, aims at giving a summary of the salient facts concerning the commercial geography of the world in a form suitable for use by students. The first chapters contain a brief review of the various causes which influence trade and determine its direction and amount. The effects of natural conditions, such as climate, geographical position, configuration of the land as determining the facilities for transport, &c., are noted, and the other economic influences which control the development of the resources of a country are also stated.

Notices of some recent Unofficial Publications.

The main portion of the book is devoted to a study of the world's commerce, in which all the principal countries are separately treated, and the different factors which have contributed to place them in their present commercial positions are emphasised. Particulars regarding the most important articles of commerce at the present time are given in the section devoted to the country in which they are chiefly produced or manufactured.

As the book is primarily intended for use in the United States, the commerce of that country receives the fullest treatment, occupying 133 pages, whereas the chapter on the United Kingdom only extends to nineteen pages, and those on Germany and France to fourteen pages each. The volume contains numerous illustrations and maps, and is provided with an index.

The Globe Geography Readers, Senior—Our World-wide Empire. By Vincent T. Murché, F.R.G.S. Pp. vi. + 392. (London: Macmillan & Co., 1904.)

This volume is a good example of the modern geographical text book. The book is arranged as a "reader," and deals with the history, topography and resources of the British Empire in a series of short chapters. A noticeable feature is the emphasis laid upon the commercial resources, both actual and potential, of the different colonies described. Special attention is given to India and Africa, the accounts of which occupy nearly two-thirds of the book. The African colonies are dealt with at considerable length, the rising countries of British Central and East Africa receiving a full share of attention. The book is illustrated, many of the pictures being examples of colour photography.

The British Nation. A History. By George M. Wrong, M.A. Pp. xxxii. + 616. (New York and London: D. Appleton & Co., 1903.)

This work aims at condensing within the limits of a small volume the salient features of the history of the British nation up to the year 1903. The subject is treated chiefly from the point of view of political development, but nevertheless about one-third of the volume is devoted to the social life of the nation. A list of useful books of reference is given at the end of each chapter. The book is provided with illustrations, plans and maps.

A Manual of Forestry. Vol. II. Practical Sylviculture or Formation and Tending of Woods. By William Schlich, C.I.E., Ph.D. Second Edition, Revised. Pp. xiii. + 331. (London: Bradbury, Agnew & Co., Ltd.)

The present volume is the second edition of the third part of Schlich's Manual of Forestry. The general arrangement of the

Notices of some recent Unofficial Publications.

first edition has been maintained, but an appendix on the distinguishing botanical characters of British trees has been omitted.

Part III. is concerned with the practical application of the fundamental principles of sylviculture, which were fully dealt with in Parts I. and II. of the preceding volume, published in 1889. The aim of the author has been to produce a handbook which shall be of practical value to the forester, and hence unimportant matters of detail and all points of a debatable character have been excluded.

The book is divided into four chapters. The first deals with the preliminary work which must be carried out before the formation of a wood can be successfully accomplished. Those most fully considered are the selection of species for particular requirements and the important questions of fencing and reclamation of the soil. The account of the fixation of shifting sands and coast dunes is of especial interest.

The actual formation of plantations, and the tending of the woods when once successfully formed, are described in some detail in Chapters II. and III. An account of the various methods of propagation and planting out is given, together with practical information in regard to pruning, thinning, and the treatment of woods for the production of large timber.

Chapter IV. is concerned with an account of the best methods of cultivation of some twenty trees indigenous to, or thriving in, Great Britain. In brief outline, the distribution of the tree, and the commercial value of its timber, are considered, followed by short notes upon the sylvicultural system most suited to the tree, its reproductive power, methods of tending, and other matters of importance to the forester.

CHAPTERS ON PAPERMAKING. VOL. I. By Clayton Beadle. Pp. 151. (London: H. H. Grattan, 1904.)

This book consists of a reprint of ten lectures which were prepared by the author in 1902 on behalf of the Battersea Polytechnic Institute and which have appeared already in the columns of "Paper and Pulp." The subjects dealt with include the technical examination of fibrous raw materials, bleaching processes, the production of art papers, the influence of water on paper and paper-materials, the chemical and physical properties of paper, and the causes of its deterioration.

OFFICIAL HANDBOOK TO THE CEYLON COURT, ST. LOUIS WORLD'S FAIR, 1904. Pp. li. + 174. (Colombo: G. Skew, 1904.)

This volume practically forms a handbook to Ceylon, only a few of the early pages and the final chapter being occupied with the classification of exhibits, the greater part of the book being devoted

Notices of some recent Unofficial Publications.

to the description of geographical features, the government and natural resources of the island.

A historical introduction by Mr. H. White supplies geographical and ethnographical information, explains the administration, and includes an account of the important irrigation works which when complete will have cost five million rupees. Illustrations are reproduced of native types, and a map of Colombo shows the extent of the breakwater and other works now in progress. The rock temples, dagobas, and religious monuments form the chief topics of the chapter on archæology. Mr. Harward gives a historical survey of the progress of education, and contrasts the antiquated, but still existing Pansala schools with those of more modern type. The colleges for higher education are noted. Economic matters are introduced by an article on the "Trade with the United States," in which Mr. Roles describes the more important commercial products, and tabulates the list of exports and imports to the States for the last three years. Writing about agriculture, Mr. J. C. Willis points out that the prosperity of the island has been very greatly dependent upon the plantations, whether of coffee, cinchona, cocoanut, or tea, together with such by-products as cocoa, citronella oil, and more recently rubber. The history of the pearl fishing industry is reviewed by Mr. Hornell, and an account of the important mineralogical assets, notably, graphite and gem stones is given by Mr. Coomaraswamy, the principal officer of the Mineralogical Survey of Ceylon which is now being carried out in conjunction with the Scientific and Technical Department of the Imperial Institute. The book contains maps and a large number of illustrations.

INDIAN AND COLONIAL COLLECTIONS.

RECENT CHANGES AND ADDITIONS.

NEW SOUTH WALES COURT.

EUCALYPTUS OILS.

(*Continued from page* 145.)

Class 2.—Oils less rich in Eucalyptol

Eucalyptus Baeuerleni, F.v.M. "Brown Gum."

This species is not important as a commercial source of oil, being found only in almost inaccessible places on Sugar-loaf Mountain.

The average yield of oil from the leaves was 0·328 per cent., containing 24 per cent. of eucalyptol.

E. propinqua, D. & M. "Grey Gum."

Occurs in New South Wales and Queensland. The average yield of oil was 0·235 per cent. The crude oil is red in colour, has a turpentine odour, and does not contain sufficient eucalyptol to render it of commercial value.

E. affinis, D. & M. "Black Box."

The crude oil is reddish orange-brown in colour, with an odour resembling that of the better class oils. The average yield was 0·259 per cent. The principal constituent was found to be a sesquiterpene. Between 165° and 183° C. 39 per cent. of the oil distilled, and this fraction contained 29 per cent. of eucalyptol.

E. lactea, R. T. B. "Spotted Gum."

The average yield of oil from the leaves of this species was 0·541 per cent. The crude oil is red in colour, with an unpleasant turpentine odour, and is practically a terpene oil, only a very small quantity of eucalyptol being found.

E. intertexta, R. T. B "Spotted Gum," "Gum," "Red Gum."

Pinene and eucalyptol are the principal constituents of the oil of this species, and owing to the predominance of the former it cannot be considered as a good class oil. The average yield was 0·395 per cent.

E. maculata, Hook. "Spotted Gum."

This species is found along the coast lands of New South Wales and Queensland, and is of importance for its timber, which is utilised locally and also exported.

The oil consists mainly of pinene and a sesquiterpene, but contains a fair quantity of eucalyptol.

Eucalyptus Oils of New South Wales.

E. microcorys, F.v.M. "Tallow Wood."

This species, which is well known as the source of a pale-coloured, hard, durable, greasy timber, occurs on the northern coast district of New South Wales and also in Queensland.

The oil is but slightly coloured, and has an odour of turpentine. It consists mainly of pinene and eucalyptol. An interesting feature shown by this and some other eucalypt oils is the increase in percentage of eucalyptol which occurs on keeping. The average yield of oil from the leaves was 0·51 per cent.

E. quadrangulata, D. & M. "Grey Box."

A species with a very limited range, being known at present only from about three localities in the State. The average yield of oil was 0·684 per cent. The crude oil is of a reddish-orange colour, with the odour of the better-class oils, and consists almost entirely of dextro-pinene and eucalyptol.

E. conica, D. & M. "Box."

The oil from this species contains a large proportion of pinene, and not enough eucalyptol to be considered a valuable oil. The average yield was 0·587 per cent.

E. Bosistoana, F.v.M. "Ribbon" or "Bastard Box."

The average yield of oil was 0·968 per cent. Although eucalyptol is present in some quantity, the oil contains too great a percentage of pinene to be of high commercial value.

E. tereticornis, Sm. "Red Gum," "Blue Gum."

This species occurs in New South Wales, Victoria and Queensland. The crude oil is orange-brown in colour, and has a marked odour of armadendrol. A sesquiterpene is present in large amount, whilst there is but little pinene or eucalyptol. The average yield of oil was 0·482 per cent.

E. gracilis, F.v.M. A "Mallee

A shrub or small tree found in New South Wales, South Australia, Victoria and Queensland. The oil contains pinene and eucalyptol, with the former predominating; aromadendral is also present. The average yield of oil was 0·901 per cent.

E. viridis, R. T. B. "Green Mallee."

The yield of oil was high, 1·06 per cent. Terpenes are present in abundance, whilst eucalyptol forms less than 10 per cent. of the crude oil.

E. Woollsiana, R. T. B. "Mallee Box."

The timber of this species is very hard, close grained, heavy and durable, and useful for bridge-decking, posts, railway

Eucalyptus Oils of New South Wales.

sleepers, and general building purposes. The oil is rich in the aldehyde aromadendrol, but contains only a small quantity of eucalyptol.

E. albens, Miq. "White Box."

This tree occurs throughout the Central Division of New South Wales and also in Queensland. The pale-coloured, hard, durable timber is highly prized for its durability. The average yield of oil is low, 0·101 per cent.; a fair quantity of eucalyptol is present, as also a considerable amount of aromadendral.

E. hemiphloia, F v.M. "Box."

This species is the common "Box" of the coast and Dividing Range, and is distinct from any of the "Box" trees of the interior. It occurs in New South Wales, South Australia, Victoria, and Queensland. The timber is pale-coloured and hard, but not of high value. The oil consists largely of pinene, eucalyptol and aromadendrol. The average yield of oil is 0·554 per cent.

E. viminalis, Labill. "Manna" or "White Gum."

This is, perhaps, the most widely distributed species of eucalyptus in Australia, as well as probably the tallest, trees measuring over 300 feet frequently being found. It occurs in New South Wales, South Australia, Victoria, and Tasmania.

The essential oil is very dark coloured, and is composed principally of terpenes, together with eucalyptol. Average yield of oil 0·354 per cent.

E. ovalifolia, R. T. B.

The crude oil is of a light orange-brown colour, and possess a rank odour. Phellandrene and a sesquiterpene are present in considerable quantity, but only a small amount of pinene. In the fresh oil eucalyptol was detected only with difficulty, but after the oil had been kept for eighteen months 10 to 15 per cent. of this constituent was found. (Compare *E. microcorys.*)

E. angophoroides, R. T. B. "Apple-top Box."

[illegible] average yield of oil was 0·185 per cent. The oil con[illegible] sesquiterpene, phellandrene, pinene, and eucalyptol.

[illegible] *Fletcheri*, R. T. B. "Lignum Vitæ" or "Box."

[illegible] crude oil is orange-brown in colour, and of disagreeable odour. Phellandrene is a prominent constituent of the oil, which also contains a fairly large amount of a sesquiterpene, a small quantity of pinene, and when freshly distilled less than 5 per cent. of eucalyptol.

Bulletin of the Imperial Institute.

AUSTRALIAN SANDARAC RESIN.

A number of samples of Australian sandarac resin, presented by the Technological Museum, Sydney, have been added recently to those already exhibited in the New South Wales Court. The new specimens are derived from *Callitris robusta*, a plant belonging to the Cypress family of the Coniferæ, and illustrate the character of the resin in the crude state and also after the clearing process, in which very dilute alcohol is employed. The specimens of sandarac originally in the Court are also derived from this species, but the clearing agent employed in this case is a weak aqueous solution of caustic potash.

Sandarac of commerce is the resinous exudation of *Callitris quadrivalvis*, and is obtained chiefly from Morocco. Occasionally consignments of Australian sandarac resin, known in Australia as "pine-gum" or "white pine resin," are now placed on the English market, but the supply of this product is irregular.

The resin exudes naturally from the trees as long cylindrical tears, but the flow is greatly increased by incising the trunk. When fresh it is pale yellow in colour, but slowly darkens, when kept, to a red brown. Sandarac is completely soluble in alcohol, ether, oil of turpentine and hot linseed oil; it quickly hardens on exposure to the atmosphere, becoming covered with a whitish "powder" due to the presence of innumerable minute cracks resulting from unequal contraction on drying; the "powder" may be removed by washing in very dilute alcohol or potash solution.

Australian sandarac has been the subject of investigation in the Scientific and Technical Department of the Imperial Institute, and the results show that the Australian product is essentially similar in chemical composition to that obtained from Morocco. In both cases the crude resin consists of a mixture of the same resin acids, with an essential oil containing terpenes; the two varieties can only be distinguished by the difference in the shape of the tears.

Sandarac has been employed for the manufacture of paper and picture varnishes from the earliest times, and it is still used, to some extent, as an ingredient in spirit and similar varnishes prepared without the aid of heat. When powdered, it is known as "pounce," and in this form is used for preparing the surface of parchment for writing. The resin is also sometimes employed as incense.

Bulletin of the Imperial Institute.

LIBRARY.—RECENT ADDITIONS.

Books and Publications, exclusive of Government Publications, presented by Publishers and others to the Library of the Imperial Institute since 25th August, 1904.

Catalogue of Books in the Victoria Public Library of West Australia. Part V. ...	(*Librarian*)
General Sir Henry Drury Harness, K.C.B	Edited by General Webber. (*Royal Engineers' Institute*)
Proceedings of the Rhodesian Scientific Association. Vols. I., II., III. ...	(*Secretary*).
Ferguson's Handbook of Ceylon, 1904–05	(*Crown Agents for the Colonies*).
Nature Teaching	By F. Watts and W. G. Freeman. (*W. G. Freeman.*)
Journal of the Mining Society of Nova Scotia. Vol. VIII., 1903–04	(*Secretary*).
Transactions of the Institution of Naval Architects, 1904	(*Secretary*).
The Mining Laws of Spain	Translated by J. A. Jones. (*The Editor, Mining Journal.*)
Egyptian Mining Law	By C. J. Alford. (*The Editor, Mining Journal.*)
Records of the Cape Colony, October, 1824 to February, 1825; February to April, 1825; April to June, 1825; June to August, 1825	By G. M'Call Theal. (*The Prime Minister of the Cape Colony.*)
Indian Art at Delhi	By Sir G. Watt. (*India Office.*)
Lectures on Iron Founding	By T. Turner. (*Messrs. Griffin & Co.*)
History of Buenos Aires Harbour	By Luis A. Huergo. (*Author.*)
Guide to South Africa, 1904–05	A. S. & G. G. Brown. (*Messrs. Sampson Low, Marston & Co.*)

Bulletin of the Imperial Institute.

Recent Additions to Library.

Applied Geology. Parts 1 and 2... ...	By J. V. Elsden.	(*Colliery Guardian Company.*)
Pamphlet on Hot Springs.		
Pamphlet on High Level Gravels of the Cape	By E. H. L. Schwarz.	(*Author.*)
Sisal Hemp Culture in Indian Tea Districts	By H. Mann.	(*Secretary, Indian Tea Association.*)
Durban: Fifty Years of Municipal History	By W. P. M. Henderson.	(*Town Clerk of Durban.*)
Calendar of Letter-books of the City of London. Letter-book F., *circa* A.D. 1337–1352	Edited by Reginald R. Sharpe.	(*Town Clerk of the City of London.*)
Australian Handbooks for 1903 and 1904		(*Messrs. Gordon and Gotch*).
Transactions of the New Zealand Institute. Vol. XXXVI. 1903	Edited by Sir James Hector.	(*Secretary.*)
Year Book of the Planters' Association of Ceylon, 1903–04...		(*Secretary*).

SCIENTIFIC AND TECHNICAL DEPARTMENT.

I.—REPORTS ON RECENT INVESTIGATIONS.

The following accounts of investigations have been summarised from a selection of the reports recently furnished to the Indian and Colonial Governments.

THE RUBBER OF *LANDOLPHIA PETERSIANA*, FROM THE EAST AFRICA PROTECTORATE.

This sample of rubber, stated to have been prepared from *Landolphia petersiana*, was forwarded to the Imperial Institute from the East Africa Protectorate in February, 1904.

The sample consisted of a single ball of rubber measuring about 3½ inches in diameter and weighing 280 grams. The ball was dark-coloured throughout, and when cut open was found to consist of an inner ball, about 3 inches in diameter, enclosed in a cover which could be easily separated. The rubber forming this outer cover was very sticky, probably owing to the changes which had occurred during transit, but the inner ball had not been so much affected. The rubber was very porous, and contained a considerable quantity of acid liquor; it was soft and rather spongy, but was satisfactory in elasticity and tenacity.

The analysis conducted in the Scientific and Technical Department of the Imperial Institute, furnished the following results:—

	Sample as received. Per cent.	Calculated for dry material. Per cent.
Moisture	17·8 ...	—
Caoutchouc	67·7 ...	82·5
Resin	11·1 ...	13·4
Dirt	3·4 ...	4·1
Ash, included in dirt ...	1·2 ...	1·5

The rubber is therefore of very fair quality, containing 82·5 per cent. of caoutchouc in the dry material, but the percentage of resin is rather higher than is desirable. In this latter respect it compares unfavourably with several specimens of the rubber of *Landolphia Kirkii* from the East Africa Protectorate, which, on examination at the Imperial Institute, were found to contain less than 5 per cent. of resin.

The Rubber of Landolphia Petersiana from the East Africa Protectorate.

A portion of the inner ball was submitted for valuation to commercial experts, who reported that it would be worth about 3*s.* per lb. in the London market at the present time, when Para rubber is quoted at 4*s.* 10*d.* per lb. A rather higher price, up to 3*s.* 6*d.* per lb., would probably have been offered for the rubber if it had been better prepared, and free from the defects which this specimen exhibited, owing to the damage sustained during transit.

No particulars were given regarding the methods employed in the preparation of the rubber, but it seems probable that these could be improved so as to prevent the inclusion in the final product of any of the acid liquid of the latex. In order to accomplish this, the freshly coagulated rubber should be subjected to pressure and well washed with water until free from impurity, after which treatment it should be thoroughly dried before being packed. The rubber thus obtained would be much superior in appearance and properties to the present specimen, and the removal of the liquid would greatly increase its stability.

HYOSCYAMUS MUTICUS FROM INDIA.

In September, 1896, a sample of *Hyoscyamus muticus,* collected in Sindh, was forwarded to the Imperial Institute by the Officiating Reporter on Economic Products, who stated that the plant is reputed to be more virulent in its medicinal action than ordinary henbane (*Hyoscyamus niger*), and might therefore repay chemical investigation. The examination in the Scientific and Technical Department of the Imperial Institute showed that the dried plant, consisting of stems and leaves, contained 0·1 per cent. of hyoscyamine, and that no other atropaceous alkaloid was present. On this account the hyoscyamine was easily extracted in a pure condition, and it was thought that the plant would probably prove to be of commercial value as a source of this alkaloid. (*Imperial Institute Bulletin,* 1903, Vol. I., p. 175.)

After the publication of these results, the Imperial Institute received specimens of the same plant from Egypt, and it was found that these also contained hyoscyamine only, but that a much larger amount was present than had been recorded for the Indian plant. It became of interest, therefore, to examine other samples of the latter in order to ascertain whether this difference in the amount of alkaloid was general or only accidental. This view was communicated to the Reporter on Economic Products, and in compliance with this suggestion

Hyoscyamus Muticus from India.

two other specimens (Regd. Nos. 16,271 and 20,189) were forwarded to the Imperial Institute from India in May, 1902, and in February, 1904.

CHEMICAL EXAMINATION OF SAMPLES.

No. 20,189.—This sample, which had been collected in the Punjab, consisted of the stems and leaves of the plant, together with a few ripe fruits from which the seeds had escaped. The stems and leaves were separated, and an analysis was made of each; the sample furnished 66 grams of stems and 150 grams of leaves.

Stems.—When treated in the manner previously described (*loc. cit.*), the stems yielded 0·36 per cent. of crystalline alkaloid, the percentage being expressed on the dry material. By fractional crystallisation from chloroform and petroleum the alkaloid was very readily obtained in the long silky needles characteristic of hyoscyamine, so that it was evident that not more than mere traces of the other atropaceous alkaloids could be present. The identity of the crystalline alkaloid was confirmed by the determination of its melting point and that of its aurichloride, 106° and 159° respectively, which prove it to be hyoscyamine.

Leaves.—The dry leaves yielded 0·38 per cent. of alkaloid, which, as in the preceding case, was easily obtained in a crystalline condition, and was indentified as hyoscyamine. The alkaloid melted at 107° C., and its aurichloride at 158·5° C.

No. 16,217.—This sample was obtained from Larkana, and is stated to have been collected during the cold season; it consisted of the stems and leaves of the plant, together with a few fruits. The whole specimen was much broken, and both stems and leaves were ground together for analysis.

The dry material yielded 0·28 per cent. of alkaloid, which, like that from No. 20,189, was obtained in crystalline form and identified as hyoscyamine.

These two samples of *Hyoscyamus muticus* from India have therefore proved to be richer in hyoscyamine than the specimen first examined, but the percentages are still much lower than those which have been recorded for the Egyptian plant. Samples of *Hyoscyamus muticus* from Egypt, which have been examined in the Scientific and Technical Department of the Imperial Institute, have yielded from 0·6 to 1·2 per cent. of hyoscyamine, and similar results have also been obtained by other investigators, whereas the richest of the Indian specimens, No. 20,189, contained only 0·38 per cent.

It appears from these analyses that the Indian *Hyoscyamus muticus* does not contain so much hyoscyamine as the same plant grown in Egypt, and that consequently it could not compete

Hyoscyamus Muticus from India.

successfully with the latter as a source of hyoscyamine or atropine (the latter alkaloid being easily prepared from hyoscyamine).

The Officiating Reporter on Economic Products states, moreover, that the plant does not appear to be abundant in any part of India, some difficulty having been experienced in collecting the small samples forwarded for examination, so that in any case commercial supplies of the material could not be obtained from India at the present time. The inquiries regarding the distribution of *Hyoscyamus muticus* in India are, however, being continued, and it is possible that the plant may yet be found in sufficient quantity to justify further action.

SEEDS OF *DATURA STRAMONIUM* FROM INDIA.

The comparative investigation of *Hyoscyamus muticus* from India and Egypt, conducted in the Scientific and Technical Department of the Imperial Institute, showed that this plant contains hyoscyamine without the presence of any other atropaceous alkaloid, but that this constituent is present in much greater amount in the Egyptian than in the Indian variety. A sample of *Datura Stramonium* grown in Egypt was also found to contain hyoscyamine, with only a trace of other alkaloid, and it was therefore desired to ascertain whether the plant obtained from India would give a similar result, and what the relative proportion of alkaloid would be in this case. For purposes of comparison a sample of the seeds of *Datura Stramonium* was collected in India and forwarded to the Imperial Institute by the Officiating Reporter on Economic Products to the Government of India.

The sample, No. 15,202, was obtained from Bushahr, and consisted of 300 grams of the seeds which possessed the usual characters. On analysis the air-dried seeds yielded 0·26 per cent. of alkaloid, which was easily obtained in the long lustrous needles characteristic of hyoscyamine, so that it was evident that not more than traces of the other alkaloids could be present. The crystalline alkaloid was identified as hyoscyamine.

This sample of the seeds of *Datura Stramonium* from India therefore resembles that from Egypt in the fact that practically the whole of the alkaloid is present as hyoscyamine, but the Indian seeds contain a smaller proportion of alkaloid, the percentages being 0·26 and 0·35 respectively. The seeds of the Egyptian *Datura Stramonium* appear, therefore, to be richer in

Seeds of Datura Stramonium from India.

hyoscyamine than those of the Indian plant, the results agreeing in this respect with those found for *Hyoscyamus muticus* but as only one sample from each country has been examined it is impossible to say definitely whether the difference is fundamental or only accidental. The percentages of alkaloid recorded for the seeds of *Datura Stramonium* grown in Europe vary from 0·16 to 0·37, but the amount usually present is probably represented by the latter figure. The alkaloid in this case also consists almost entirely of hyoscyamine.

The nature of the alkaloid present in the seeds of *Datura Stramonium* appears, therefore, to be quite constant, whatever the country of origin may be, but whereas the Egyptian seeds were found to contain as much alkaloid as European seeds, the sample from India yielded a lower proportion.

THE UTILISATION OF LIGHT WOODS AS CORK SUBSTITUTES.

1.—THE AMBACH WOOD OF THE SUDAN.

A consignment of this wood was forwarded to the Imperial Institute, through the Foreign Office, by the Sudan Government, in November, 1902, with the request that the possibility of its commercial utilisation might be investigated.

The Ambach reed (*Berminiera elaphroxylon*), which is stated to grow in enormous quantities in the Bahr-el-Ghazal Province and along the Upper Nile, produces a wood characterised by extreme lightness and buoyancy. At present it is only utilised by the natives for making rafts, but it was thought that some other commercial use could be found for the material, possibly as a substitute for cork.

The sample forwarded for examination consisted of a number of the cylindrical stems of the plant, from 5 to 6 inches in diameter, and covered with a thin, smooth bark. The wood was exceedingly light and soft.

The specimens were brought to the notice of timber merchants and experts, among whom the wood appeared to be quite unknown, and most of them regarded it as a great curiosity on account of its extreme lightness, but thought that it would have no commercial value.

With reference to the suggestion that the wood might serve as a substitute for cork, it is improbable that any such use

The Utilisation of Light Woods as Cork Substitutes.

would be made of it in this country, though no doubt it could be so utilised locally. A large number of similar light woods occur in other countries, but none of them are so satisfactory as cork in impermeability to water and continued buoyancy, and their use is restricted to local requirements. Enquiries have been made as to the suitability of these light woods for making life-belts, floats, etc., but the manufacturers have reported that they could not be utilised for such purposes.

The most practicable suggestion which was received regarding the possible utilisation of the wood was that it might prove suitable for the manufacture of wood-pulp, provided the cost was not too great. On account of the lightness and looseness of texture of the ambach wood it was thought that the mechanical treatment necessary with harder woods used for the purpose could be dispensed with, and the pulp prepared direct from the stems after removal of the bark. It was recognised, however, that even if the ambach wood proved suitable for pulp manufacture, the cost of transporting such a light, bulky material from the Sudan might be so heavy that competition with the other woods now used for the purpose would be rendered almost impossible, but it was thought that if the wood were freed from the bark and compressed into bales by an ordinary cotton-press before shipment, the freight could be materially reduced. The experts suggested that if this difficulty regarding the cost of transport could be overcome it would be advisable to forward a consignment of about 10 cwt. of the wood in order that practical trials of its suitability for pulp manufacture could be made.

As a result of these preliminary enquiries 10 cwt. of ambach wood were forwarded to the Imperial Institute through the Foreign Office, but in the accompanying letter it was stated that at the existing rates of transport in Egypt and the Sudan the cost of forwarding large consignments of the wood to England would be almost prohibitive, but that it might be found practicable to float the wood down the river, at the period of high Nile, for the greater part of the distance.

Upon the receipt of this consignment arrangements were at once made for the commercial trials. A sample of the wood was first submitted to a firm of pulp manufacturers using the "sulphite" process, but the results of their experiments were not very satisfactory. They reported that the fibre obtained by the sulphite process was short, brittle, very dark coloured, and difficult to bleach, but stated that possibly a better result might be obtained by the "soda" process.

Arrangements were therefore made to have the wood treated by the latter method, but in this case also the bleaching of the product proved to be a very troublesome matter. The firm

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who made the experiments reported that they considered the pulp yielded by ambach wood unsuitable for fine papers owing to the difficulty experienced in obtaining it of good colour, and in their opinion the only means of utilising it would be for the manufacture of coarse brown paper, where no bleaching would be required. The price obtainable for ambach wood for the preparation of brown pulp would be very low, however, and would probably be insufficient to cover the cost of transport. It appears, therefore, to be certain that ambach wood could not be utilised successfully for the manufacture of wood pulp in this country or in Europe.

Samples of the ambach wood have been supplied to several timber merchants and brokers, who have exhibited the specimens in their sale-rooms, but up to the present no commercial enquiries have been received.

During the course of the enquiry it was suggested by one of the timber experts consulted, that the ambach wood, although of no commercial value itself, might nevertheless prove useful in the transportation of some of the heavy timbers of the Sudan. In many countries where heavy timbers have to be transported by water it is customary to fasten them to lighter woods, the buoyancy of which enables them to be rafted down the rivers. It might perhaps be possible to utilise the ambach wood in a similar manner for exporting some of the heavy timbers which occur in the forests of the Bahr-el-Ghazal, and which could probably be floated down the river in this manner at the period of high Nile.

Although all attempts to utilise this remarkable wood have been unsuccessful so far, it is intended to take advantage of any other opportunities that may present themselves to bring it under the notice of manufacturers and others who may possibly be able to find some use for the material.

2. "AWOU" AND "AFE" ROOTS FROM LAGOS.

Specimens of these two roots, the wood of which, like that of the ambach tree, is characterised by extreme lightness and softness, were forwarded to the Imperial Institute by the Government of Lagos for the purpose of ascertaining their suitability for use as substitutes for cork. No particulars were supplied at the time regarding the origin of the roots or the uses to which they have been applied in the Colony, but from information subsequently received it appears that the trees which furnish these roots are very abundant throughout the Colony, growing either in swampy or sandy soil, and that the roots are merely dug up and used without any preparation. They serve principally as floats for fishing nets and other similar purposes, and it is stated that they do not become sodden in the water. Owing to the lightness and compressibility of the

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woods it was thought that they could probably be utilised as substitutes for cork in this country.

The woods have been carefully examined in the Scientific and Technical Department of the Imperial Institute, and in addition, have been submitted to a number of technical experts and manufacturers likely to be interested in such materials.

The "Awou" roots consisted of large flattened pieces, which were roughly elliptical or wedge-shaped in transverse section, with a longer diameter up to 6 inches. The wood was a light yellowish colour, very light, soft, and easily compressible, and was covered with a thin buff-coloured bark.

The "Afe" roots were smaller than the above, more cylindrical in shape, and had a dark brown bark. The wood was darker in colour than that of the "Awou" roots, but in general characters and properties the two were very similar.

The woods had approximately the same specific gravity as that of an average piece of cork which was taken for comparison, the "Awou" wood being a little heavier and the "Afe" wood a little lighter, than the cork. The possibility of utilising the woods as cork substitutes would depend, however, upon their impermeability to water, and some comparative experiments made to test this point did not give very encouraging results.

Pieces of "Awou" and "Afe" wood, from which the bark had been removed, were found to have gained 89 and 154 per cent. in weight respectively after complete immersion in water for 24 hours, whereas the weight of a similar piece of cork had only increased 15·4 per cent. under the same treatment. After immersion for ten days the two woods had absorbed over three times their weight of water, and floated with about five-sixths of their volume submerged, whilst the cork had only absorbed a little over half its weight of water and retained a much greater buoyancy than the woods.

In these experiments the water had free access to the wood on all sides, and it was thought that perhaps better results would be obtained if pieces of the roots covered with bark were employed, in which case absorption would chiefly occur at the ends. Pieces of both roots were therefore cut without removing the bark, and, after attaching light weights, these were allowed to float on water in order to test their behaviour. The results of these trials were rather contradictory, however, as certain pieces of both roots did not readily absorb water, and retained their buoyancy under these conditions for considerable periods, whereas others speedily became waterlogged and almost completely submerged.

It was evident from these results that the woods are much

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more permeable to water than cork, and they would, therefore, be much less suitable for many of the purposes for which the latter is employed, on account of its continued buoyancy, such as in the manufacture of floats and life-belts. Samples of the woods were submitted to makers of these articles, but they reported that the material would be quite useless for such purposes The ready permeability of the woods by liquids would also prevent their general utilisation as stoppers for bottles. Pieces of the woods, after being roughly rounded, can be easily compressed into the neck of a bottle to form a tight-fitting stopper, but if the bottle were inverted or placed upon its side the stopper would become sodden, and allow the contents to leak slowly

The woods might possibly be used locally as substitutes for cork stoppers, as similar light and soft woods are employed in Jamaica and elsewhere, but it is quite certain that with an abundant supply of cork no such use would be made of them in this country. A large number of soft, light woods, the so-called "cork woods," which possess characters very similar to these ' Awou " and " Afe " roots, are known to occur in many countries, but so far as is known it has not been found possible to utilise these commercially, and they only serve for local use. The very heavy freight which would have to be paid upon such products, owing to their extreme bulkiness, is an important factor which would require to be considered in any attempts to find an export market for these Lagos roots.

Enquiries have also been made regarding the possibility of utilising the " Awou " and " Afe " woods for the manufacture of wood pulp for paper making, but, as in the case of ambach wood, the reports were unfavourable, as they were found to be unsuitable for the preparation of anything beyond a brown wood pulp for coarse paper.

THE COMMERCIAL UTILISATION OF CORUNDUM, FROM PERAK, FEDERATED MALAY STATES.

A specimen of grey-blue corundum, weighing about 3 oz., was forwarded to the Imperial Institute by Mr. Leonard Wray, Curator of the Perak Museum, in November, 1903. He stated that this material had been collected near Ipohe, in the Kinta District, where the mineral occurs in more or less waterworn lumps in the drift which is worked for tin. At present no use is made of the corundum, but it was thought that if it proved to be of marketable value considerable quantities could be procured. Mr. Cecil Wray, the Resident Magis-

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trate of Kinta, had also collected a large quantity of the same mineral at Koban Sungii Kaiadi.

Subsequently Mr. Leonard Wray forwarded to the Imperial Institute a larger sample weighing nearly 5 lb., which he had collected at Pulai Sungei Raia, also in the Kinta District. He stated that the mineral occurs in quantity at or near Pulai, and that there would probably be no difficulty in getting from 10 to 20 tons per month, judging from the amount he saw in the mines.

These two samples, the colour of which varies from pale blue to bluish grey, are exactly similar in characters. No well-developed crystals are visible to the naked eye, the mineral occurring in compact, finely granular masses, which appear to be made up of microscopic crystals. Most of the pieces are more or less rounded by water action, though the exact manner in which this was brought about is not apparent.

The mineral is rather harder than some well crystallised corundum from Ceylon, which was available for comparison. Its specific gravity varies from 3·75 to 3·90 according to the degree of compactness of its texture. The higher figure is exceeded by few specimens of corundum, except ruby and sapphire, which reach 4·06.

An analysis made in the Scientific and Technical Department of the Imperial Institute gave the following results:—

Silica	SiO_2 ...	0·15 per cent.
Alumina	Al_2O_3 ...	97·10 „
Lime	CaO ...	0·50 „
Magnesia	MgO ...	trace
Combined water ...	H_2O ...	2·41 „

The percentage of alumina is greater than in any sample of corundum which has been analysed except ruby and sapphire. The amount of water is rather high.

COMMERCIAL VALUATION.

Corundum is used mainly for abrasive purposes, in the same manner as emery. The finer qualities are also employed in place of gemstones in the movements of clocks and watches. It has been proposed to utilise it as a source of metallic aluminium, but at present other less refractory and cheaper compounds of the metal are preferred for this purpose.

In determining the value of corundum for abrasive purposes, whether it be employed as a loose powder or embedded in cement in the form of discs, a trial on a large scale is necessary. In no other way can it be ascertained if the material satisfies industrial requirements, as not only hardness, but toughness, is important. The liability of some varieties to split into thin plates along the pseudo-cleavage which follows

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certain planes of decomposition is very objectionable, as instead of irregular points and edges, which are effective for grinding purposes, flat surfaces are produced.

This characteristic seriously diminishes the value of most Indian corundum, which was formerly exported in considerable amount to Europe, but is now unable to compete with the extensive deposits of the mineral which have been developed in the United States and Canada, and the artificial products "carborundum" and "alurundum." Corundum is now mined in India mainly for local use and for export to China, only a small quantity being sent to Europe or America. On the other hand, the granular structure of the corundum from Perak seems calculated to increase its value for abrasive purposes.

The material from Kinta was sent to a commercial expert in corundum, for opinion as to its value. He stated that the material would be of value for abrasive work, and that it might be worth from £15 to £25 a ton for such purposes. If it would take a high polish it could be used for the movements of clocks and watches, and might be sold at a higher price. Actual trial on a commercial scale was, however, necessary.

In June, 1904, a further sample of corundum, weighing 32 lb., was received from Mr. Alma Baker, of Bala Gojal, Perak. This is in large lumps, some weighing as much as 8 lb., and is in all respects similar to the previous samples.

There seems every reason to believe that if this corundum can be obtained in the amounts which Mr. Leonard Wray believes to be the case, it could be sold either for abrasive purposes or for use in the movements of timepieces at remunerative prices, but in order that its capabilities may be properly determined by trial on a large scale, a consignment of not less than 3 or 4 cwt. would be necessary in order to determine its precise commercial value as an abrasive agent, together with a smaller amount, say 7 lb., of the clearest and most compact material for trial in the manufacture of watches and clocks.

If, therefore, it is considered advisable to proceed further with this enquiry, the Imperial Institute will be glad to be informed whether these larger consignments can be supplied, in which case arrangements will be made with experts to carry out practical trials on the lines indicated above.

GRAPHITE FROM THE CHATISGARH DISTRICT OF THE CENTRAL PROVINCES OF INDIA.

These specimens of graphite were forwarded to the Imperial Institute for examination and valuation by the Reporter on Economic Products to the Government of India, in January, 1904.

The occurrence of graphite in the neighbouring Kalahandi State was described in 1902 by Professor T. L. Walker, formerly of the Geological Survey of India, in a memoir on the geology of the State (Memoirs of the Geological Survey of India, vol. xxiii., part 3). It occurs there in connection with a series of garnet-sillimannite rocks, which have received the name of Khondalites, or more correctly, Kandhalites. These overlie the granitoid gneiss, and form the greater portion of the hilly region of the State. At the surface they are frequently decomposed to a lateritic clay. The graphite is widely distributed in small flakes and occasionally found in greater amount in veins and pockets. At Koladi-Ghat veins from 1 to 2 ft. in diameter in clay are met with, while at Densurgi there are bands, composed of calcite and graphite, running north-west and south-east, parallel to the primary strike of the gneiss. These bands are supposed by Professor Walker to result from the decomposition of a graphitic gneiss.

A sample of graphite from the Kalahandi State was forwarded to the Imperial Institute in 1901, and was examined in the Scientific and Technical Department. Afterwards it was submitted to technical trials by experts, who reported that although it was almost entirely deficient in flake, and produced a very dead powder, it might be used to a limited extent for the purpose for which the commonest Ceylon dust plumbago was employed, but its value would not be more than 3*l.* to 4*l.* per ton delivered in barrels in London (Technical Reports and Scientific Papers published by the Imperial Institute, 1903, p. 43).

The Patna State lies immediately to the north-east of Kalahandi, and here also the hilly country appears to be formed of garnetiferous gneiss, whilst as early as 1877 the occurrence of graphite was noted at Daramgarh, near the river Barabailat Noi, and at Domaipali (Ball, Records of the Geological Survey of India, vol. x., p. 183).

The following are the particulars of the samples from the Patna State now under consideration:—

No. 20,560.—Surface pickings, Dharapgarh mine. Dharapgarh is probably the same locality as that formerly written Daramgarh. The sample consists of schistose graphite with veins and lenticles of quartz, felspar and calcite. These impurities were eliminated in sampling for analysis.

Graphite from the Chatisgarh District of the Central Provinces of India.

No. 20,560-1.—Lower level Dharapgarh mine. Similar to No. 20,560, but containing rather less visible impurity.

No. 20,561. -Surface pickings, Marna mine (about two miles west of the town of Patna). Graphite less markedly schistose, with yellow specks of decomposed biotite and other ferruginous material.

No. 20,561-1.—Lower level, Marna mine. Similar to No. 20,561.

No. 20,562.—Surface pickings from Dundel mine. Schistose graphite with pale yellow decomposed mica and other decomposition products.

No 20,562 1.- Lower level, Dundel mine. Schistose graphite with greenish-white and yellow decomposition products.

These samples were analysed, with the following results, the analysis of the specimen from Kalahandi State being added for comparison :—

—	No. 20560	No. 20560–1	No. 20561	No. 20561–1	No. 20562	No. 20562–1	Specimen from Kalahandi State.
Sulphur	trace	—	—	—	—	—	—
Volatile matter ...	0·38	0·89	2·61	2·08	2·15	3·58	3·89
Moisture	0·38	0·42	0·79	0·14	0·23	1·23	1·12
Carbon dioxide ...	10·60	12·14	—	—	—	—	—
Fixed carbon (by difference)	40·95	37·00	79·91	69·67	63·70	54·73	63·12
Ash	47·69	49·55	16·69	28·11	33·87	40·47	31·87
Colour and nature of ash	light brown	light brown	dark brown	light brown	light brown	light brown	Silica, alumina, lime, ferric oxide.

The specimens were then forwarded to an expert for report as to their commercial value. He stated that they had not the binding quality which is essential in graphite employed for the manufacture of crucibles. Graphite which was wanting in this characteristic might, however, if it contained a very high percentage of carbon, be used in making crucibles which were only subjected to one heating and were then ground up and remoulded.

No. 20,561, which contained 79·91 per cent. of carbon, was not sufficiently pure for this purpose, and would only be worth about 10*s.* per cwt., being, like the higher grades of Bohemian "black-lead," only available for polishing stoves and similar purposes. The sample No. 20,561–1 was unequal in character, but some pieces were as good in quality as anything in sample No. 20,561.

Graphite from the Chatisgarh District of the Central Provinces of India.

The remaining specimens were, it was stated, of little value.

The same samples were subsequently submitted to a firm of crucible makers for technical trial, who stated that they possessed little or no commercial value in their present form for their purpose, and would require much more thorough dressing and cleaning to render them saleable. It was difficult to say what value they would then have, but judging from appearance, samples Nos. 20,561 and 20,561–1 might possibly pay to treat, though the value of the cleaned product would not be high. In the others the graphite was so closely intermixed with rock and other impurity that the cost of cleaning would be prohibitive. They further stated that the supply of graphites containing less than 85 per cent. of carbon was very much in excess of the demand, and they consequently commanded but a very low price.

It seems clear that these graphite deposits can only be worked at a profit by separating and cleaning them on the spot, and shipping only higher grade material to Europe.

Near Passau, in Bavaria, similar material has been treated in the following manner: –

After being carefully hand picked, the crude graphite was ground up in a horizontal mill of the ordinary grist or buhr stone type, when the graphite formed small scales, while the impurities were reduced to fine powder. The graphite was then separated by bolting silk or by an air-blast. When the impurities were harder the ore was pulverised by stamps or edgestone mills, which have a combined grinding and rolling action.

The best material available in these mines contained only 53·8 per cent. of graphite, while the best concentrates had as much as 89·2 per cent.

The chief impurity in the Bavarian graphite was mica, which does little harm. There was considerable loss in the tailings, but that is immaterial if the supply of crude ore is sufficiently large.

In most cases, however, it is necessary to resort to wet methods of separation. The ore is ground up fine with water and is then passed through a number of settling tanks; sometimes as many as 18 are used. The impurities settle in the first few tanks, and the graphite, in gradually improving grade, in the others. The slime is subsequently pumped into large presses under a pressure of several atmospheres. The cakes produced are then dried and crushed for the market.

The process of separation by the wet method is facilitated if the crushed material is first dried by heat, so that the particles float more easily on water. This result is obtained still more effectually if the finely divided graphite is, after being dried, exposed to the vapour of petroleum, which it rapidly absorbs.

II.—GENERAL NOTICES RESPECTING ECONOMIC PRODUCTS AND THEIR DEVELOPMENT.

COTTON CULTIVATION IN EGYPT.

The cultivation of cotton in Egypt, although dating from very early times, was not undertaken as a regular industry until about the year 1820, at which date perennial irrigation was introduced into the Delta of the Nile. The cultivation gradually increased, and received a great stimulus from the deficiency produced by the American Civil War. After the conclusion of the war the progress of the industry in Egypt still continued, although in many other countries the cultivation rapidly declined. Recent improvements in irrigation and drainage have increased the opportunities for cotton growing, and the area under cultivation appears still to be extending. It is estimated that at the present time no less than one-half of the land in the Delta is devoted to this crop. The total cotton area of Egypt now amounts to between 1,500,000 and 1,750,000 acres, of which about 90 per cent. is in the Delta. The success of cotton culture in Egypt is so striking that it is worth while to call the attention of those concerned in cotton cultivation on British soil to the circumstances connected with the development of the Egyptian industry.

Egyptian cotton possesses certain characteristics which render it particularly valuable in certain branches of the textile industry. The fibre is fine, and varies in length from one to one and a-half inches; it is generally more lustrous, and "mercerises" better than American "upland" cotton, and commands a higher price, but is not so long, fine and valuable as the "Sea Island" variety.

In connection with the Egyptian cotton industry, two books which have been published recently are of great importance. One of these works is a report by M. Henri Lecomte (1) to the Governor of Senegal, on the results of a mission to Egypt, and treats of the cultivation, preparation and exportation of Egyptian cotton. The other is entitled "Notes on Egyptian Agriculture," by George P. Foaden (2), Secretary of the Khedivial Agricultural Society, Cairo, and includes an account of cotton growing on Egyptian soil.

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1. *Le Coton en Egypte. By Henri Lecomte. Pp.* 162, *with illustrations.* (Paris: Augustin Challamel, 1905.)
2. *Notes on Egyptian Agriculture. By George P. Foaden, B.Sc. Pp.* 61, *with illustrations.* United States Department of Agriculture. Bureau of Plant Industry—Bulletin No. 62. (Washington, 1904.)

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CLIMATE.

The chief characteristic of the Egyptian climate is the scarcity of rain, the rainfall in average years only amounting to 1·5 inches at Cairo and 7·8 inches at Alexandria. From April, the month in which the cotton is planted, until November, when the last crops are gathered, little or no rain falls, the chief rains being experienced between November and March.

The mean annual temperature in the Delta varies from 69·1° F. at Alexandria to 70·3° F. at Cairo. Further up the river, at Assouan, it reaches 80° F. The extremes of temperature observed at Alexandria are 45·1° F. as a minimum and 99·3° F. as a maximum. At Cairo, as would be expected from its greater distance from the sea, the range is wider, the extremes being 36·5° and 109·2° Fah

It is evident from these meteorological data that the climate of Egypt is very favourable to the growth of the cotton plant The deficiency in the supply of rain to the plant is compensated by the water obtained from the Nile by the elaborate system of irrigation which has been established.

For agricultural purposes the year is divided into three seasons, known as winter, summer and Nili, the last being the season in which the Nile overflows its banks. The different climatic conditions prevailing at these seasons enable a variety of products to be grown, and, in virtue of the comparatively high temperature and the ample supply of water, two or three crops are obtainable from the same land every year.

SOIL.

The arable soils of Egypt consist almost entirely of alluvial deposits, but since the conditions prevailing at their formation were not always the same the soil does not everywhere present the same physical properties and chemical composition, and the nature of the deposit varies with the depth. Recent borings at different localities have shown that the thickness of the deposits varies from about 36 to 110 feet.

In Upper Egypt, the ancient bed of the river constitutes what is known as the Nile Valley. The river here, in times of flood, extends over the land on each side and deposits its alluvium; it afterwards contracts and occupies a comparatively small channel. In this way the arable land of the Nile Valley has been won from the desert.

The Delta, on the other hand, has been won from the sea by the rapid deposition caused by the mingling of the river with the salt water. A difference has consequently arisen in the nature of the soil of the two regions. In the Nile Valley, the deposition of the alluvium has been effected by gravitation alone, and the soil is therefore not so rich in clay as is that of the Delta, where the salt of the sea has caused a more rapid precipitation of the argillaceous matter, and has also made the land more saline.

The typical soil of the Delta is a heavy, black clay, which is difficult to work, but is fertile, and well adapted to cotton cultivation. In those districts which yield the best cotton the soil consists of a mixture of clay and sand, which is always accompanied by a large proportion of vegetable matter due to the growing of clover for fodder. The soils of other localities vary from a sandy loam to almost pure sand.

Few chemical analyses of Egyptian cotton soils have been made, and it is inadvisable, therefore, to give any figures to represent their general composition. It appears that, on the whole, the soil is more deficient in nitrogen than in any other constituent, and the application of nitrogenous manures is usually found to exert a beneficial effect on the growth of the cotton plant in Egypt. Some analyses of typical cotton soils of Egypt, which were made by Dr. Mackenzie, Director of the School of Agriculture at Ghizeh, appear to indicate that Egyptian soils which are rich in lime are relatively poor in iron and alumina, but contain a large proportion of magnesia.

VARIETIES OF COTTON.

Cotton plants have been grown in Egypt from time immemorial, but previous to the year 1820 there was no systematic cultivation. About this time a variety of cotton was introduced into the Delta from the Sudan, and was grown for many years under the name of "Jumel." "Sea Island" and Peruvian cotton also are said to have been introduced into Egypt at an early date. In course of time from these various forms the "Ashmouni" cotton plant was evolved, which is the oldest of the varieties now cultivated in Egypt. The principal varieties grown at the present time are "Ashmouni," "Mitafifi," "Abassi," and "Yannovitch." In addition to these there are a number of forms of less importance.

"*Ashmouni.*"—This variety, though at first grown in the Delta, is now cultivated almost exclusively in certain districts of Upper Egypt. The average yield of unginned cotton from this plant amounts to about 1,300 lb. per acre. On ginning, a comparatively small proportion of fibre is obtained, amounting to only 30 per cent. of the seed cotton. "Ashmouni" cotton is of a brownish colour, but not so dark as "Mitafifi"; it is less valuable than the latter, and does not yield such fine qualities of lint.

"*Mitafifi.*"—The "Mitafifi" variety is the most important cotton of Egypt. The seeds of this plant are black, and bear small green tufts at their ends. The fibre is fine, very strong, from 1·3 to 1·4 inches long and of a reddish-brown colour. It

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is said that the colour is affected considerably by salt, the cotton plants grown on the more saline soils furnishing the darkest coloured cotton. "Mitafifi" cotton gives a higher average yield than any other variety, yielding, on average soils, from 500 to 600 lb. of lint per acre. The cotton is gathered easily, and on ginning, gives a good proportion (33–35 per cent.) of lint. Another advantage possessed by "Mitafifi" is that the plant is less affected by climatic variations than many of the other varieties.

"*Abassi.*"—This variety is of comparatively recent introduction, and was obtained by selection from "Zafiiri," which in turn, was obtained from "Mitafifi." The plant is very hardy and able to withstand drought and other adverse climatic conditions. The fibre is white, and in this respect differs from that of all the other varieties cultivated in Egypt at the present time. The cotton is fine, silky, 1·2–1·4 in. long, and of good strength; it is not so strong, however, as "Mitafifi" cotton, and is more difficult to gin.

"*Yannovitch.*"—This cotton is supposed to have originated by hybridisation from "Mitafifi" and "Gallini." It has been cultivated for about seven years, and the best qualities are grown on the salt soils of the northern part of the Delta. The fibre is very strong, 1·4–1·6 in. long, and is the finest and most silky of all the Egyptian cottons. A great disadvantage attaching to the cultivation of this variety is that the bolls fall to the ground as soon as they are ripe, and require to be constantly collected.

"*Gallini.*"—This variety closely resembles "Sea Island" cotton. The plant grows well on salt lands, but quickly suffers from lack of water, and is late in ripening. Owing to these peculiarities, and also to the fact that the cotton presents certain difficulties in ginning, due to its length and fineness, the cultivation of this variety has gradually declined.

"*Sea Island.*"—The cultivation of the true "Sea Island" cotton in Egypt has been abandoned almost completely on account of the same causes which led to the decline of the "Gallini" variety.

There are a number of varieties of less importance grown in Egypt, among which may be mentioned "Zafiri," "Hamouli," "Bamia," "Hariri," "Psikha," and "Maskas." None of these forms is cultivated to any great extent.

All these Egyptian cottons, with the possible exception of "Bamia," are considered to be varieties of *Gossypium barbadense.*

Reference must be made to the so-called "Hindi" cotton of Egypt, which is said to be the old native variety supposed to

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have been derived from *Gossypium herbaceum*. The seed of most Egyptian cotton used for sowing appears to be accompanied by a small proportion of the seeds of this variety, and, in consequence, the resulting crops are of poorer quality The "Hindi" plant can be distinguished readily by the fact that the boll opens in four or sometimes five valves instead of three. The fibre is about 1 in. in length, and is comparatively coarse and of inferior quality.

SEED SELECTION.

The quality of the seed employed for sowing has received attention in the past from only a small proportion of Egyptian cotton growers. As in India, the custom of ginning cotton in central factories, where little or no effort is made to keep different varieties of seed apart, has resulted in the distribution of seed of a mixed nature to the cultivators who depend on the merchant for their supplies. Moreover, as has been pointed out already, the seed commonly contains a certain proportion of "Hindi" seed, which greatly detracts from its value.

The subject is now engaging the attention of the Khedivial Agricultural Society, who are furnishing cotton growers with specially selected seed at cost price, payment for which is made to the Government agents in the course of the collection of the ordinary taxes.

CULTIVATION.

It was formerly the custom in Egypt to leave the cotton plants in the ground for several years, but this system of cultivation has now been replaced almost entirely by the practice of sowing the plant anew every year. The former method had the advantage that it demanded less labour and that the bolls ripened more quickly ; the chief reason for its abandonment was that it precluded the possibility of obtaining several different crops in the same year

The repeated cultivation of the same plant on any particular land would ultimately cause the soil to be exhausted of certain constituents to the detriment of the crop. For this and other reasons, a rotation of crops is practised. The system now most commonly adopted is a two-year rotation of the following character :—

Year.	Winter.	Summer.	Nili.
First year	Clover	Cotton	—
Second year... ...	Beans or wheat	—	Corn or fallow

Usually the cotton is preceded by clover, but sometimes by

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maize. In the latter case the land is left fallow during the winter, that is, between the cutting of the maize crop and the planting of the cotton.

In order to prepare the land for sowing, it is ploughed thoroughly and deeply three or four times and is afterwards thrown into rough ridges about 35 in. apart. The soil should be quite dry when the seed is sown, but should be watered well directly afterwards. Since the cultivation of cotton is carried on in Egypt by means of irrigation the plantations must be laid out in such a manner as to facilitate watering. The land is divided into sections by a second series of ridges running at right angles to the ordinary ridges, so that the latter are usually not more than 36 ft. long.

The cotton is generally sown between the 15th of February and the middle of April, the actual date varying according to the locality. Before sowing, the seeds are soaked in water for 24 hours, and any which rise to the surface are rejected. The seeds are planted at a depth of about 3 in., from 8 to 15 being placed in each hole and immediately covered with earth. The plants appear above the soil in from 10 to 12 days, according to the weather experienced. The plantations are watered from time to time, from 8 to 10 waterings being given before the first crops are gathered.

When the young plants have become well established the fields are hoed in order to destroy weeds and to loosen the soil. Before the first watering, which is given usually about 35 days after sowing, the hoeing is sometimes repeated, and the young plants are thinned out, only the two strongest being allowed to remain. The second watering takes place about 25 or 30 days after the first, and when the land has become fairly dry, it is again hoed. About three weeks later the fields are watered for the third time and are subsequently hoed again. The water is now applied more frequently, during June, July and August two waterings being given each month if possible. During these summer months, however, in which the Nile is low, the amount of water available is somewhat limited, and for this reason the frequency of watering is restricted by the Irrigation Department. It is estimated that the amount of water supplied to the cotton plants from the time of sowing until the first crop is gathered is roughly equivalent to a rainfall of 31–35 in.

A brief description may be given here of the manner in which the watering is effected. The water is supplied by the canals of the irrigation system, but as these are below the level of the soil, the farmers must employ some method of raising it to the surface. This is effected either by such primitive means as "shadoofs," "sakias," or the Archimedian screw, or else by rotatory pumps worked by steam, or even by electricity supplied

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from a distance. The water is then distributed throughout the farms by a rough and somewhat leaky system of canals. From the canals the water is conducted round the fields in small ditches; from these, in turn, it is allowed to run along the furrows separating the ridges on which the cotton grows. The tops of the ridges always remain above the water.

Since the ripening of the cotton bolls is not simultaneous, but extends over a period of two months or more, the whole crop cannot be gathered at once, but is generally collected in three portions at intervals of about a month. The picking is done by women and children. In the Delta, the first crop is gathered towards the middle of September, but in Upper Egypt, where "Ashmouni" is grown, it is collected at the end of August. The last portions of the crop are picked in November. The first picking usually represents about 35 per cent. of the total crop, whilst the second and third pickings form about 45 per cent. and 20 per cent. respectively. The last picking is of inferior quality; it is not mixed with the other portions of the crop, but is sold separately.

GINNING.

After the cotton has been harvested the crop is sold in the form of seed cotton, and is then forwarded to a ginning factory. These ginning establishments are situated usually in localities where facilities exist for transport both by rail and by water. During the season, from September to May, the factories work continuously night and day. Ginning is effected almost invariably by the Macarthy self-feeding single-action roller gin, of which from 50 to 100 are employed in an Egyptian factory. This machine is particularly suitable for ginning long-stapled cotton; it effects its purpose without either crushing the seed or injuring the fibre.

MANURING.

Success in the cultivation of cotton in Egypt is greatly enhanced by judicious manuring. Owing to the need of the soil for organic matter, stable manure must form the basis of the applications. The amount available on the farms is that from eight or ten working bullocks for every hundred acres, of which one-half is usually under cotton. This quantity is supplemented by that from the cows and buffaloes kept for milking, and from the mules used for transport. This supply, however, is not sufficient to produce full yields of cotton, and artificial manure, therefore, should be employed in addition. The stable manure, in the accumulation of which earth is used instead of vegetable litter, is spread over the land previous to the last ploughing before planting. The quantity applied amounts to ten or fifteen tons per acre; as much as thirty tons is sometimes employed, but when used at this rate there is never enough on the farm to

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supply all the fields. Old manure is always used by the best growers since fresh manure is apt to cause rank growth, late maturity, and the production of inferior fibre.

Superphosphate of lime is the most important of artificial manures as it is found to check coarse growth, to encourage ripening, and to improve greatly the quality of the fibre. The dressing applied is about 400 lb. of this manure per acre; the superphosphate generally used contains from sixteen to eighteen per cent. of soluble phosphoric acid. It has been found that basic slag does not answer as a substitute for superphosphate.

Potash manures have not been found of any benefit in Egypt except, perhaps, in the case of light soils. This may possibly be accounted for by the fact that the alluvial soils of Egypt are very rich in potash.

The application of soluble nitrogenous manure to the soil is found to be very advantageous to the growth of the young plant which is unable to obtain the necessary nitrogen rapidly enough from the stable manure, even though the latter may contain quite as much as is theoretically required. Care must be taken, however, that such nitrogenous manures are not applied too freely since they tend to produce luxuriant growth, with consequent retarded ripening and deficient yield. As the results of numerous experiments instituted with the object of ascertaining whether nitrate of soda or sulphate of ammonia is the more suitable substance to employ as a source of nitrogen to the plant, it has been found that the application of a mixture of 125 lb. of the former with 50 lb. of the latter gives excellent results. The beneficial effect of such manure is evident even when the cotton follows a crop of clover, or when a dressing of stable manure has already been applied.

The application of the superphosphate is made at the same time as that of the stable manure—that is, just before the last ploughing. The soluble nitrogenous manure is applied after the cotton field has received its first watering. The manure, mixed with a little earth, is applied to the roots of the plant and hoed in, after which the plants are watered for the second time.

PRODUCTION AND EXPORT.

The following table gives the cotton crop of Egypt for the years 1897—1903, the season extending from September 1st to August 31st:—

Year.	Millions of Lbs.	Year.	Millions of Lbs.
1897-1898	645	1900-1901	538
1898-1899	558	1901-1902	644
1899-1900	637	1902-1903	584

The greater part of the cotton is exported, but a small amount is used in the villages for the manufacture of coarse materials; the

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cotton employed in this way is, however, usually of very poor quality. During recent years an increase in the local consumption has taken place owing to the erection of two cotton mills—one at Alexandria and the other at Cairo. Most of the cotton seed is also exported, but a certain quantity is crushed in the Egyptian oil mills and employed in the manufacture of soap, the cake being exported to England as "undecorticated cotton cake." Egyptian cotton seed is rich in oil, giving on the average a 25 per cent. yield.

The following table gives the quantities of cotton and cotton seed exported during the years 1902 and 1903. It may be mentioned that during the year 1903 the average weight of the Egyptian bale of cotton was about 750 lb.

COTTON.

Countries to which exported.	1902.	1903.
	Bales.	Bales.
Exports from Alexandria to—		
United Kingdom	322,514	351,745
Germany	19,126	19,422
Belgium	9,604	12,670
Spain	31,781	24,910
United States	106,565	84,819
France	78,875	70,608
India	2,443	836
Italy	63,068	60,728
Japan	11,322	9,498
Russia	121,343	55,424
Austria	92,249	75,989
The Netherlands	327	—
Greece, Turkey and other countries	3,753	1,798
Exported from Port Said and Suez	700	5,445
Total	863,670	773,892

COTTON SEED.

Destination.	1902.	1903.
	Bushels.	Bushels.
United Kingdom	16,991,964	14,754,776
Marseilles	987,795	739,897
Other Continental ports	829,359	563,166
Total	18,809,118	16,057,839
Local consumption	1,679,281	2,268,000

Bulletin of the Imperial Institute.

THE PROGRESS OF COTTON CULTIVATION IN THE SUDAN.

A short account of cotton cultivation in the Sudan, with special reference to the districts watered by the Blue Nile and Dinder Rivers has already been given in the *Imperial Institute Bulletin*, this vol., pp. 120–121. A number of reports on cotton growing in other districts of the Sudan having been received recently at the Imperial Institute, it is now possible to give a more detailed account of this industry.

In the reports on cotton growing at the Shendi Experimental Farm during 1902–1903, it is stated that this farm was established chiefly with the object of ascertaining whether cotton can be grown successfully on irrigated land in the Shendi district. One of the most important investigations which has been carried on is the determination of the best time for planting cotton in the Sudan. From the first year's results, it appears that cotton grows well whether sown in September and October after the overflow of the river, in March and April as in Egypt, or in June and July before the full flood. It is found that each period presents certain advantages, and that prolonged study will be required in order to decide which is the best.

During the period from August to November, 1901, the following varieties of cotton were sown:—"Ashmouni," "Galioubi," "Yannovitch," "Abassi," "Mitafifi," and some American cotton which had been grown in Egypt. The "Ashmouni" cotton gave the most satisfactory results. The "Yannovitch," "Abassi," "Mitafifi," and American varieties yielded small crops, but the "Galioubi" failed entirely. Samples of the "Abassi" and "Mitafifi" were submitted to experts in Alexandria, who reported that the cotton had not suffered much owing to the change of climate. The products were of fair staple and colour, and would be classed as "good fair" in the Alexandria market, where they would meet with a ready sale. It was stated that the "Yannovitch" and American cottons had both deteriorated, and that the latter would find no market except for mixing with low grade Egyptian cotton.

During March and April, 1902, seed of the "Abassi," "Mitafifi," and "Yannovitch" varieties was sown. Satisfactory results were obtained except in the case of the "Yannovitch," and the view that cotton of good quality can be grown in the Sudan was confirmed. The yield amounted to 400 lb. per acre in the case of the "Mitafifi" variety, and from 450 to 500 lb. in the case of the "Abassi" and "Yannovitch." The "Yannovitch" cotton was again unsatisfactory, being inferior to the "Abassi" both as regards colour and staple.

Bulletin of the Imperial Institute.

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The yields obtained with the cotton sown in June and July, 1902, were less favourable than had been anticipated, probably on account of deficiency in the water supply. From these experiments the conclusion was arrived at that "Abassi" cotton appears to be the variety best suited to the Sudan conditions. The "Mitafifi" cotton was of fair staple, but rather coarse. The "Yannovitch" crop was of fair length and fineness, but was lacking in strength, and inferior to the "Yannovitch" cotton of Lower Egypt.

The country between Gedaref and Gallabat on the banks of the Rahad is said to be suitable for the introduction of cotton, but the industry could not at present be undertaken on a large scale owing to lack of population. In the Markas of Gallabat a considerable amount of cotton is grown in the villages, the area under cultivation amounting to about 840 acres. The cotton is imported by the Abyssinians, who, however, will not purchase any cotton unless it is quite white.

In the Bahr-el-Ghazal Province it is reported that the land between the ironstone plateaux and the perennial swamps, and also the alluvial land bordering the rivers far up their course is nearly all suitable for cotton growing, but that labour is not easily obtainable, and that transport is difficult. It is considered that if work were started in the neighbourhood of Meshra er Rek, Wau and Shambe, transport could be much simplified by lines of portable tramways. The area available in the vicinity of these places amounts to about 14,000 acres. Little, if any, irrigation would be required, since the rainfall is usually sufficient. Cotton appears to be capable of growth in all parts of the Bahr-el-Ghazal Province except on the ironstone plateaux, and even there it grows on the sandy slopes.

The Dinka country, which constitutes the alluvial plain between the slopes of the ironstone plateaux and the sudd basin, seems to be well adapted for cotton growing. It comprises an area of 14,000 square miles, of which at least one-half is suitable for the purpose. At the present time, however, owing to the difficulties of transport and the scarcity of labour, and also to the fact that a large part of Dinka-land is still unknown, and not yet brought under Government control, the areas actually available for cotton cultivation are confined to particular districts. Land transport is practically impossible from May to December, except by means of carriers. There are not sufficient carriers available, however, owing to lack of population among the carrying tribes, and to the fact that the Dinkas will not undertake this work, even if paid handsomely for it. From January to April carts can travel in the alluvial plains where the ground has been cleared of grass and bushes, and it is suggested that automobiles might be employed during this

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season. At several stations in the Bahr-el-Ghazal pack bullocks are used for transport.

The southern and eastern parts of the province have not yet been thoroughly explored, but a large area is undoubtedly suitable for cotton cultivation there.

On the western side the industry might be carried on in the vicinity of Chak Chak, where transport would be facilitated if the Chell River channel through the sudd to the Bahr-el-Ghazal River were open for navigation. In the area between Wau and Dem Zubeir, the valleys are suitable for cotton growing, but very little labour is available

In the Sennar Mudiria a cotton plantation at the Experimental farm was sown with "Mitafifi" seed on July 12th, 1903, and the plants were watered occasionally by means of "shadoofs" and "sakias" Four crops of cotton were obtained, the first of which was gathered on 10th November and the last on 31st December. The average proportion of "lint" obtained amounted to 31·2 per cent. of the weight of the unginned cotton. The cotton was clean and of satisfactory quality, and compared favourably with "Mitafifi" cotton grown in Egypt. It was submitted to an expert, who reported that the staple was fine, of good length, even and strong, and that the product had more the character of "Yannovitch" than of "Mitafifi" cotton.

The following reports refer to three samples of cotton which were grown in Sennar, on land obtaining its supply of water from the rainfall only. The first of these samples consisted of the product known in Egypt as "Hindi" cotton, a variety said to have been derived from seed imported into the Sudan at a very remote period. This cotton is an inferior kind, and introduces a grave difficulty into cotton cultivation in Egypt and the Sudan, as its seed becomes mixed with that of all the good varieties, with the result that every field of Egyptian cotton contains some "Hindi" plants. The cotton is white, differing in this respect from all other Egyptian cottons except the "Abassi" variety. The fibre is of poor quality, weak, and 0·75–1 in. long. The "Hindi" plant is of luxuriant habit, produces large leaves, and is rather later than other Egyptian varieties, from which it can be distinguished by the fact that the boll opens in four divisions instead of three.

The second sample was derived from Egyptian seed which was probably introduced into the Sudan by Mumtez Pasha in 1871. This cotton showed evidence of great deterioration, and had lost its colour, although it still possessed in a slight degree the general characteristics of Egyptian cotton.

The third sample was grown from recently imported Egyptian seed. The cotton was slightly harsh, and 1¼ in.

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long; it preserved the general properties of Egyptian cotton, and, on the whole, was very promising. It is suggested that, instead of continually importing fresh seed from Egypt, it would be advisable to adopt a system of selection with the object of obtaining a variety of cotton acclimatised to the particular district.

Two samples of cotton grown at Deberki, on the Dinder River, have been described. One of these was an Egyptian variety of brown colour and good staple. The other, which, although labelled "Mumtez," was probably of the "Abassi" variety, consisted of very short, white cotton mixed with brown pods.

Considerable interest is being taken in cotton cultivation on the Dinder River, in the Sennar Mudiria. The cotton was formerly grown on the upland areas as a rain crop, but a small quantity is now being cultivated near the river in order to obtain facilities for irrigation. The variety chiefly grown in this Mudiria is "Mumtez," but "Abu Hareira" is also cultivated to a small extent.

About 60 miles south of Suakin the Baraka River forms a large delta, in the centre of which stands Tokar, the only permanent village in the district. This delta is the only tract in the Suakin Mudiria which offers any prospects of development in cotton growing. The area of the Baraka Delta is approximately 400,000 acres, but probably not more than one-fourth of this is available for cultivation.

The soil of the Delta is exceedingly rich and fertile, and very retentive of moisture. The rainfall, although sufficient in favourable years for the growth of "dhurra" and "dukhn" (varieties of *Sorghum vulgare*), is inadequate for cotton growing, and the only cotton area of real value is that which is inundated by the annual overflow of the Baraka River. The volume of water discharged by the river at this period varies greatly from year to year. During the last 13 years the area of land flooded has varied from 150 acres in 1893 to 30,000 acres in 1900. In those years in which the overflow is deficient only a very small area is devoted to cotton. In the year 1903, the overflow was of average extent, and the land brought under cultivation amounted to 15,000 acres, which was divided equally between cotton, "dhurra," and "dukhn."

The cotton at present cultivated in this region is sown in October and gathered in February. Egyptian seed is employed, and is freshly imported every year. The plants grow well, and yield a product which is said to be but little inferior to the cotton grown on Egyptian soil. The methods of cultivation are careless and wasteful, but this is partly attributable to the scarcity of population. The average yield of cotton (un-

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ginned) is about 600 lb. per acre, or 200 lb. of the ginned material per acre. It is probable that the total production could be increased more readily by improving the methods of cultivation than by extending the area cultivated, but in any case the ultimate possibilities are strictly limited by the inadequate water supply. It is stated that the area capable of cultivation might be largely increased, and even doubled, by the introduction of a system of irrigation by means of canals and banks, but that the normal flow of the river could not possibly suffice for the irrigation of more than about one-tenth of the total area of the Delta.

A sample of cotton grown from native seed in the Dongola Mudiria in 1903 was submitted to experts, who reported that the staple was short and the seed covered with down, and recommended the cultivation of an Egyptian variety, such as "Mitafifi" or "Ashmouni," in preference to the indigenous cotton.

The following is a summary of a report on the prospects of the cotton industry in the Sudan for 1904.

Early in the year, 650 acres were planted with cotton between Berber and Khartoum. The greater part of the cotton produced in this district is used locally, very little remaining for export.

About 450 acres were sown in the Sennar Province, and a small area in the Kassala Province. The cotton crop in these regions is purchased by Abyssinian merchants. It is proposed that "Abassi" seed should be sent to these Provinces in future in order to improve the production of white cotton for the Abyssinian demand, and also with the view of obtaining a staple suitable for the European market by the time that the railway from Suakin to Berber has been completed.

In the Dongola Province, which is one of the best for cotton growing, about 3,300 acres have been planted. The chief difficulty encountered in this Province is that of transporting the cotton to the railway.

It was estimated that during the summer of 1904, a total area of from 7,000 to 9,000 acres would be planted with cotton in the different Provinces of the Sudan.

Great assistance in the cultivation of cotton has been rendered by the Sudan Government, who have purchased a large quantity of seed, and distributed it to planters on condition that payment should be made after the sale of the crops. Arrangements have also been made for the purchase of the cotton at a fixed price. An "Agricultural Circular," containing valuable instructions on cotton cultivation in English and Arabic, has been circulated among cotton growers in the various Murdirias. The experiments carried out in the Sudan during recent years have demonstrated that Egyptian varieties of cotton can be grown

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successfully in the Sudan, and yield a larger profit than the indigenous cotton. The cultivation of Egyptian varieties is therefore recommended, and it is stated that in subsequent years the Government will render no assistance in the disposal of native cottons. The object of this decision is to maintain the reputation of Sudan cotton by discouraging the export of inferior native varieties which would be liable to prejudice the market against Sudan cotton as a whole.

COTTON GROWING IN GERMAN COLONIES.

Early in the year 1900 earnest attention was drawn in Germany to the extent to which its cotton industry was dependent for supplies of raw material on the United States and other foreign countries, and to the desirability of endeavouring to obtain German cotton from German soil. In that year the German Colonial Economic Committee, composed of scientific specialists, set to work, with the aid of the Government, to promote this object. The following account, the data for which appear in the *Tropenpflanzer*, and other official publications, will give some idea of the progress that is being made as the result of a series of well-planned experiments. The experimental cultivation is conducted on strictly scientific lines, the general supervision and instructions as to procedure being issued by the Committee in Berlin, to whom reports of the results obtained are furnished periodically; scientific experts being despatched from time to time to the Colonies to inspect and report on the progress and development of the operations.

The table below gives an idea of the magnitude of the cotton industry in Germany; it shows the weight and value of the raw cotton used in that country, that is to say, the remainder left after deducting the exports of raw cotton from the imports:—

Year.	Weight. Millions of lbs.	Value. £
1896	534	9,744,350
1897	602	10,409,100
1898	712	10,725,200
1899	672	10,157,800
1900	616	14,156,350
1901	666	13,429,800
1902	679	14,116,200

Of the raw cotton entering Germany in 1902, 77 per cent.

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came from the United States, 9 per cent. came from Egypt, and the remaining 14 per cent. from British India and other places. The only cotton exported from German colonies was a small quantity from the Pacific, estimated in 1899 as being of the value of £3,500. The number of spindles in Germany in 1900 was 8,100,000, which increased to 8,434,600 in 1903, in which year there were 390 mills.

TOGO.

The colony of Togo, in West Africa, possesses a climate suitable to the cotton plant, which has long been grown there by the natives; it is thickly populated, and the inhabitants are endowed with considerable intelligence. On these grounds the Committee selected it as the scene of their first efforts for developing the cultivation of cotton. In May, 1900, they formed a plan for obtaining negro farmers from the United States to conduct experiments in cotton growing; this scheme received the energetic assistance of the Imperial Government and financial support from the German Colonial Society and from numerous firms. Aid was given by the Tuskegee Normal and Industrial Institution in Alabama in selecting the members of the expedition, and in equipping it with a baling press, gins, ploughs, waggons, agricultural machines, and a large quantity of cotton seed. The staff comprised an American cotton expert as leader, two negro cotton farmers, and one negro mechanic.

As regards climate, Togo may be divided into three districts. South Togo, which is the coast district, has two rainy seasons, the first from April to June and the second in September and October; the latter is not so much to be relied upon as the former. The annual rainfall varies from 20 to 35 in. In Middle Togo, which is partly mountainous, the annual rainfall ranges from 40 to 100 in., and is about 60 in. at Misahöhe. The two rainy seasons of the coast here almost merge into one; from December to February is the dry season. In North Togo the rainfall has not yet been determined, but it is less than in Middle Togo.

Several experimental gardens were already in existence, and these, as well as the officials of the government stations and the owners of plantations, rendered active assistance in furthering the objects of the Committee. The operations that were carried on in 1901 and the following years comprised the trial of native and foreign varieties of cotton on experimental farms; the purchase of cotton from the natives at many centres in order to induce them to cultivate it throughout the country; the organisation of a system of ginning and baling stations so as to prepare the purchased cotton for export; the construction of bridges; the improvement of roads and of transport facilities

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so as to cheapen the cost of bringing the cotton to the coast: and the instruction of natives at the experimental farms in improved methods of growing and handling cotton. The plan of getting American negro cotton farmers to settle in the country in numbers is deferred for future consideration, though a few have been obtained to help in carrying out the above operations.

The American expedition arrived at the port of Lome, in Togo, at the end of December, 1900, and proceeded to Misahohe, a station in Middle Togo, about 68 miles inland. There they selected the village of Tove as the site for their first experiments. The waggons, at first, had to be left behind at Lome, as no horses were available, and the natives were afraid to draw them, though willing to carry them on their heads.

The soil at Tove is a stony, red clay subsoil, covered with a black loam, varying in thickness from a thin layer on the high grounds to many inches on the low grounds The thin layer of soil is especially well adapted to cultivation during the season of heavy rains, as the water runs away quickly and allows air to penetrate to the roots. About 34 acres were planted from March to June, 1901, and an experimental field, with sections devoted to different varieties of cotton, and receiving various manures, was laid out. This formed the first planting season; the rainy season began in March with a very light fall, April brought frequent light rain and was favourable for planting. In May the rain was very heavy, but did not injure the young plants; in June the rain was frequent and heavy. The growth at first was very promising, but heavy rain in July, followed by mists and cold nights, ruined the crop. Only a few bales were harvested, and no results were obtained from the experimental field.

The second planting season was in the months July and August, 1901, when 20 acres were sown with Egyptian and American cotton. Less rain was experienced in September and October, but cloudiness and fogs continued; at the end of October the sunshine increased and the temperature rose, improving the prospects; in November and December light rain fell. The yield from this planting, however, could only be reckoned as "half a crop." The results of the year pointed to the late summer as the best season for sowing, thus avoiding the heavy rains.

Although the locality was regarded as fatal to draught animals, it was decided that a trial should be made; so 20 horses and 20 oxen were obtained from the interior. These arrived at the end of February, 1901, and were used for ploughing and carting; but they were attacked by the tsetse fly, and most of them died in May and June, and the rest in September. Notwithstanding their short life, it was calculated

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that ploughing by horses is cheaper than employing natives for this purpose, as a horse only costs 4*l*., or less; whilst four men are necessary to draw the same plough that one horse would draw, and they only accomplish two-thirds as much work, and are paid 9*d*. a day each as wages.

By July, 1901, the native workmen had overcome their fear of being thrown down and run over by the waggons, so the machinery was loaded into these and brought from Lome to Tove. A ginning house was erected, and an appliance for working the gins by man power was constructed. By the end of the year 23 bales of cotton had been ginned and baled, part of it being cotton grown on the experimental farm and part of it native cotton grown on farms in the Mishohe District, where the natives cultivate it as a secondary product with yams. It was found that 1,800 lb. of native seed cotton (that is, cotton with the seed still attached to it) were required to produce 500 lb. of lint (that is, the cotton fibre), whilst 1,500 lb. of seed cotton grown from American seed gave, as in America, one bale of 500 lb. of lint.

At this period, that is, at the end of 1901, it was estimated that if 25 pfennig (3*d*.) is paid to the natives for 3 pfund* of seed cotton, a bale of 500 pfund weight can be delivered at Bremen for 12*l*. 15*s*., this sum being made up as follows:—

	£	s.	d.
1,800 pfund of native seed cotton (yielding 500 pfund of lint, that is 1 bale) at 1*d*....	7	10	0
Ginning by man power	1	0	0
Pressing ,, ,, ...	0	5	0
Transport from Tove to Lome, 68 miles ...	1	5	0
Shipping expenses	0	5	0
Freight to Bremen	2	0	0
Sundries, landing expenses and insurance...	0	10	0
	12	15	0

This sum proved to be capable of reduction in many directions as the work of the Committee progressed. The quantity of seed cotton requisite to give 500 pfund of lint can be reduced by improving the varieties of seed sown. Ginning and pressing by animal power is cheaper than by man power, and when steam is employed these charges will be still further reduced; the bulk of the bale will also be less, and this will diminish the freight. Improved roads and a railway will reduce the cost

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* A German pfund is one-half kilogram and is equivalent to 1·1 lb. English.

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of bringing the cotton to the coast, and thus, in the future, the total may be reduced to the following estimate:—

	£	s.	d.
1,500 pfund of seed cotton at 1*d.*	6	5	0
Ginning by steam power	0	10	0
Pressing „ „	0	5	0
Transport to Lome by railway, 120 kiloms. (75 miles)...	0	10	0
Shipping expenses	0	5	0
Freight to Bremen	1	5	0
Sundries, landing expenses and insurance...	0	10	0
	9	10	0

In 1902, as a result of the experience of the previous year, the sowing at Tove was deferred until June and July; no excessive rain was experienced, yet the yield was small, being only about 400 pfund of seed cotton per hectare (180 lb. per acre) The area cultivated was 86 acres, and 8 bales of ginned cotton were obtained; of these 5 bales came from 49 acres of American, and three bales came from 37 acres of native cotton.

Examination into the cause of the unsatisfactory results at Tove led to the suspicion that they were due to a vegetable parasite, the fungus *Neocosmospora vasinfecta.* This is the cause of the well-known "Frenching" or "Wilt disease" of the cotton plant in the United States; a disease which infects the soil permanently, and for which no remedy has been found other than to discover varieties capable of resisting its attacks. Whether the disease was introduced into Togo in the seed brought from America, or whether it was already in the Togo soil, has not been determined; but the circumstance suggests the need for exercising great precaution when sowing imported seed, in the search for superior varieties. The gall-like bodies of *Heterodera radicicola* were also often observed on the roots, and among insect pests were the locust and the red bug (*Dysdurcus suturellus*).

In July, 1902, a set of experimental plots was planted at Tove, the cotton being placed in rows 4 ft. apart, and with a distance of 30 in. between the plants; each plot was one-tenth of a hectare (one quarter acre) in area. On these the effects of various manures was tried; two-thirds of the manure was put on before the planting, and one-third in September, when the last ploughing but one was given. The results obtained with American cotton were as follows:—

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Plot.	Manure.			Yield of Seed Cotton.	
	Description.	Weight applied in pfund per plot.	Equivalent in lb. per acre.	Pfund per hectare.	Equivalent in lb. per acre.
1	Unmanured ...	—	—	375	167
2	Cotton seed ...	166	740	637	284
3	Kainit	30	134	1,480	660
4	Kainit	30	134	1,080	482
	Phosphate .	45	200		
5	Phosphate ...	45	200	522	233

These results point to potassium manures (kainit) being especially valuable for fibre crops ; a similar result to that obtained in the experiments conducted in Ireland on flax growing (this *Bulletin*, Vol. I., p. 197) ; but it should be observed that in Egypt the use of potassium salts is attended with practically no increase in yield on the ordinary alluvial soil of the Delta. The value of various manures in cotton cultivation, in relation to different soils, is one of the most important problems in the subject.

A similar set of plots planted with a variety of native cotton gave no results. This is explained by the circumstance that the native plant grew and ripened very slowly, and was seized by the disease before the fruit was set ; whilst the American cotton got ripe much quicker, so that the cotton was formed before the disease had made sufficient progress to prevent ripening.

Attention devoted to the native cottons of the interior showed that almost every single locality produced a different kind of cotton. A trial made with the native cottons of the Misahöhe and Atakpame Districts gave very good results, one-tenth of a hectare (one quarter acre) yielding 138 pfund (equivalent to 615 lb. per acre) of seed cotton, with white and long fibre. The fibre amounted to 32 per cent. of the seed cotton. This experiment was conducted on some freshly reclaimed land.

A cotton which appeared to be *Gossypium religiosum*, L., was found in the Misahöhe and Atakpame Districts. Under cultivation it grows luxuriantly, and bears 50 to 100 fruits, the lint is long, white and silky ; the seeds are small, smooth and black, with a small brown tuft at the end. On the whole, this was the best of the cottons examined.

From Kpando a kidney cotton was obtained, that is, a variety having its seeds adhering together ; these are smooth and black, and the lint is fairly long and silky, but the plant grows slowly and gives a small yield. This was thought to be a variety of Sea Island cotton (*G. barbadense*, L.), which had

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formerly been imported and had made its way up the river Volta, near which Kpando is situated. From Sokodé and Bassari came another variety resembling American "Upland" cotton in many respects. The flower leaves are yellow with a bright red patch at the base. The lint is short and rough, and varies from white to brown. The seeds are large and brown, with adhering down. It has a quick growth and a large yield, and is probably *G. punctatum*.

G. religiosum and *G. punctatum* seemed to be the varieties that should be selected for cultivation.

As regards draught animals the Tove station was not nearly so unfortunate in 1902 as in the previous year. Four oxen obtained from Atakpane, which is situated 50 miles further inland, were alive and well at the end of 13 months. Of five inoculated oxen, four were alive after having been at Tove for seven months , and of three horses, one was alive at the end of seven months, and one worked for three months before succumbing. Four mules had been purchased and were in course of trial. The use of draught animals is of the greatest importance in enabling the cotton to be grown, ginned, baled and shipped cheaply.

As the climate of the coast differs from that of the interior, it was decided to make experiments in 1902 at Lome and in several neighbouring localities, but owing to drought the yields were only small. At Lome, American, Peruvian and native cotton were planted. Scarcely any capsules of the Peruvian cotton ripened ; the American cotton, which was planted at the end of June, grew very well at first, and looked as if it would give as good a harvest as in the United States, but a drought set in, with the result that the plants began to lose their leaves and unripe fruit, and the yield was only 463 pfund per hectare (206 lb. per acre) of seed cotton

The native cotton, which was also planted at the end of June, grew well at first and flowered from 10 to 15 days later than the American, but the drought stopped its growth. The crops would have been better if they had been planted a month earlier.

In addition to the work of experimental cultivation, the system of buying seed cotton from the natives at many places throughout the country was energetically carried on, and the success of this branch of the enterprise was very encouraging. Seed was also distributed to the natives. A number of gins were sent to different centres, so that by removing the seed from the lint the weight that had to be carried to the baling press at Tove was diminished by two-thirds, and the seed remained on the spot and could be used for manuring or sowing.

The American negro farmers proved themselves of great service, working harmoniously both with Europeans and natives, and were invaluable in instructing the latter.

The harvest of 1902 amounted to 50,000 pfund of ginned cotton. Some of the Togo cotton examined in Germany was reported to equal, as regards cleanness, "good middling" American ; the staple was somewhat uneven, varying from 22 to 30 millimetres (0·8 to 1·2 in.) ; the fibre was strong, yellowish in colour, and somewhat harsh to the touch.

The latest reports, namely, those published in August and November, 1904, show that most satisfactory progress is being made in the various sections of the Committee's work. The harvest of 1904 was estimated at not less than 1,000 bales of 500 pfund each (550,000 lb.), and of a quality equal to the better kinds of American cotton. The Committee are guaranteeing the natives 30 pfennig for every 3 pfund of seed cotton (1·09*d.* per lb.). Great attention is being paid to the instruction of the natives in the cultivation and handling of cotton. A school for this purpose has been established at Nuatscha, in the Atakpame district ; it is conducted by the American negro farmers, and over 50 natives, coming from different parts of the country, attend it. It is hoped that these will later find employment as instructors in their home districts.

Togo cotton is rising in the estimation of the Bremen Cotton Exchange, and a cotton sample, the result of crossing American with native cotton, was reported to be "fully good middling" of about 30 millimetres staple (1·2 in.), of a value of 75 pfennig per half kilogram, on February 24th, 1904 (8·18d. per lb.).

The Reichstag has sanctioned a loan of 400,000*l.* for the construction of a railway from Lome to Palime. The latter town is in the neighbourhood of Misahöhe and the Tove experiment station. Experiments on the immunisation of animals against the disease caused by the Tsetse fly are going on; and in August, 1904, a plant pathologist started for Togo to investigate the diseases of the cotton plant. It is intended to hold a Cotton Exhibition at the end of the year.

German East Africa.

In German East Africa a Biological and Agricultural Institute was established in June, 1902, at Amani, which is situated about 10 hours' journey from the coast town of Tanga. This institute is placed in the charge of a director, with a staff of European assistants, and has 620 acres of land attached to it for experimental purposes. The experiment station already established at Mombo, which is about 55 miles from Tanga, was also placed under the director's supervision. The institute is devoted to the investigation of various points of importance to tropical agriculture, and has assisted in the work of extending cotton cultivation.

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In the "Mitteilungen" of the Institute, No. 7, December 28th, 1903, the Director reports the results of three experiments in cotton growing that were concluded in October, 1903. In each case Egyptian seed was used. The first experiment was carried out at the village of Makayuni, near Mombo. The field, which was nearly two acres in extent, was sown in December, 1902, with Egyptian seed, and the harvesting was finished in October, 1903, when it was found that the yield was equivalent to 606 lb. of ginned cotton per acre. The cotton was expected to fetch more than the 70 pfennig per kilogram (3·82*d.* per lb.), guaranteed by the Colonial Economic Committee. The second experiment was conducted at Mombo, where a field of nearly one acre was planted in January, 1903, with Mitafifi seed. The harvest lasted from August to October, and the yield was equivalent to 1,269 lb. of seed cotton and to 441 lb. of ginned cotton per acre, that is, 34·7 parts of ginned cotton from 100 parts of seed cotton. The third experiment was also made at Mombo in a field of 2·1 acres, which was sown in January and February of 1903. The harvest lasted from August to October, and the yield was equivalent to 2,159 lb. of seed cotton and to 592 lb. of ginned cotton per acre; that is, 27·4 parts of ginned cotton from 100 parts of seed cotton.

The yields from these fields were thus very encouraging, but those from two other larger fields which were sown later were considerably less; it was expected that the average yield from Egyptian cotton in Mombo would be about 223 lb. of ginned cotton per acre.

In the years 1900 and 1901 the Colonial Economic Committee concentrated most of its efforts on the work in Togo, but when such encouraging results were obtained in that colony, the Committee raised a sum of 15,000*l.* from colonial and industrial circles, and, in the spring of 1902, widened the area of its operations by including German East Africa, the Cameroons, German South-West Africa and Asia Minor. Owing to local circumstances the encouragement of cotton growing in German East Africa has followed somewhat different lines to those adopted in Togo; and the Committee has aimed at interesting the missions, the mercantile firms, the plantation owners, and the "communes," which the Government has established, rather than the individual natives, although this last method has not been entirely neglected. The work has been carried on by guaranteeing premiums and advances, by supplying seed, gins and presses, and by engaging German-American cotton farmers as experts to report and give advice.

From the report published in July, 1903, it appeared that favourable results had been obtained from trials of cotton cultivation in many places in the colony, and that about 1,000 pfund of cotton, grown from Egyptian seed, had been exported,

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and had been reported, both in Manchester and Bremen, to be a good substitute for Egyptian cotton. The Committee guaranteed to certain communes and planters a premium of 7*l.* 10*s.* for every hectare planted with cotton (3*l.* per acre), but no payment was to exceed 150*l.*; they also undertook to buy ginned cotton, if of the quality of American cotton, at 25 pfennig per pfund (2·73*d.* per lb.), and if of the quality of Egyptian cotton, at 35 pfennig per pfund (3·82*d.* per lb.). A route for sending cotton from Mwanza, on the Victoria Nyanza, to Europe had been found by sending it in dhows to Port Florence, and thence by rail to Mombasa, on the coast. One of the East African planters had been sent to the United States to study the cultivation and handling of cotton there.

Later information is given in reports published in 1904 Two samples of German East African cotton examined at Bremen were thus described:—(*a*) Value on January 21st, 1904, about 90 to 92 pfennig per half kilogram (9·82*d.* to 10·04*d.* per lb.); it is of exceptional character and staple, the latter is only here and there a little mixed. (*b*) Value 1 to 1·05 mark per half kilogram (10·91*d.* to 11·45*d.* per lb.); it is much above the average; the staple is very good, it is clean, and a little rougher than Yannovitch.

At the planting season 77,000 lb. of Mitafifi, Abassi, Yannovitch and Upper Egyptian seed were required. In the northern and southern coast districts over 4,900 acres were sown. This autumn's harvest is expected to exceed 1,000 bales of Egyptian cotton weighing 500 pfund each; and it is estimated that in 1905 the area under cotton will be 20 times as much as in this year.

The Kilwa district was reported to possess about 250,000 acres of land suitable for cotton. The Committee is now preparing to develop cotton cultivation on a large scale in the Rufiji District, as over 1,700,000 acres of excellent cotton land are available there, and the Rufiji River is navigable for 90 miles. In the upper part of the Rufiji Delta, near Mohorro, a site for a school of instruction in cotton cultivation, and experiment station, has been selected, and 250 acres of land are being cleared for the purpose. The school is under the management of a German-American, who is to conduct experiments with a view to determining the best of the different varieties of cotton plant and to introduce improved methods of cultivation. The scholars, after a course of two years, are to introduce the new methods into the neighbourhood of their homes.

The railway at Tanga is found to greatly aid the extension of cotton production, and the building of another railway from Dar-es-Salaam to Mrogoro has been sanctioned by the Reichstag. In the south of the colony an exploration is in progress with a view to a railway from Kilwa, on the coast, to Lake

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Nyassa. It is found that the natives here take readily to cotton planting, and the Kilwa commune is placing 5,000 acres under cultivation.

In August, 1904, an agricultural exhibition was held at Dar-es-Salaam, and prizes were awarded for cotton exhibits. In this district each owner of a hut, of which there are 28,000, is to be induced to plant at least half a hectare (1¼ acre) with cotton.

CAMEROONS.

The development of cotton cultivation for export has not advanced so far in the Cameroon Colony as in Togo and German East Africa; nevertheless, a start has been made. An expedition in 1902 to the hinterland established large cotton fields in the Lake Chad district; the product of these is at present being used by the natives for their own purposes. In July, 1903, a trial of Ecuador seed in the coast district was reported, and the product was valued as equal to the best North American kinds. By the reports of 1904 it appears that the Committee are obtaining several thousand pounds of cotton from the Garua Country in order to determine its quality. Garua is described as a land with great future prospects for cotton; it is 500 miles from the coast, but being on the Binue River, a tributary of the Niger, there is ready transport to the sea.

Cotton cultivation is now being introduced into Bali-land, the Committee having supplied 6,600 lb. of native seed from Togo, and the necessary machines. The West Africa Victoria planting Company is making a beginning by planting 740 acres. The cotton will be pressed into loads of about 66 lb. each for the plantation labourers to bring to the coast. The mission at Bali is also joining in the cultivation.

GERMAN SOUTH-WEST AFRICA.

The insurrection of the Hereros is delaying for the present the progress in cotton cultivation, but samples have been obtained from the colony and reported on. Samples from Okohandya resembled Sea Island cotton and possessed a wonderfully long and fine staple; they were valued at 1 to 1·70 mark per half kilogram (11*d.* to 18*d.* per lb.). Cotton from Warmbad, in the south, was also found to be like Sea Island cotton. A sample of cotton grown in the Outyo district was like Chinese cotton, but was of longer staple, and of a value above middling American.

NEW GUINEA, &c.

In New Guinea seed is provided by a firm at Kuragakaul, and free transport of the cotton harvested is promised.

The Committee also affords assistance to German companies operating in Borneo, South Brazil, Morocco and Asia Minor. An account of the report on cotton cultivation in Asia Minor, made for the Committee by a German expert, is to be found in this *Bulletin*, 1903, Vol. I., p. 40.

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SISAL HEMP IN INDIA.

The prospect of establishing Sisal hemp cultivation in India on a sound commercial basis may be considered from two points of view. On the one hand it would be a step in the right direction towards the extension of the white-rope fibre industry which, although advocated by administrative officers in India for some time past, has not, so far, attained important commercial dimensions. On the other hand, the tea planters who have struggled through a period of over-production and the vicissitudes due to a fall in the price of silver, and who at the present time find their commodity heavily taxed in this country, are enquiring whether Sisal hemp is a product which may be expected to yield a profitable return, and one which will supplement the tea crops during times of adversity.

Taking first the subject of Indian plants yielding fibre, which might be utilised in the manufacture of rope, a number have been suggested from time to time, and samples of fibres from several of these have been submitted to the Scientific and Technical Department of the Imperial Institute for examination and report. Among indigenous or well-established Indian plants there are species of Crotalaria, Hibiscus, Abroma and Sida ; among introduced plants Sisal hemp (a variety of Agave), and Mauritius hemp (*Furcraea gigantea*) are the most important. Of these, *Crotalaria juncea*, known as Sunn-hemp, is a recognised Indian product, with an established position in the London market. It passes under the names of Bombay, Madras, Dewghuddy, and Jubbulpore hemp, or Allahabad Sunn-hemp, and it is probable that these varieties formed the greater proportion, if not all, of the recorded amount (9,967 tons) of East Indian hemp stated to have been received in London during the first nine months of this year. The prices obtained have fluctuated between 10*l*. and 15*l*. per ton at a time when Manila hemp was realising an average price of about 30*l*. per ton, and Indian Sisal hemp about 25*l*. per ton. Of the other plants mentioned, although some of the samples were favourably reported upon, only Sisal hemp and other species of Agave have been laid out in plantations. Since Mauritius hemp and Sisal hemp are both well-known commercial products, there is the distinct advantage in selecting these for cultivation, that a market already exists, and in the case of Sisal hemp, at any rate, the demand is considerable, and may be expected to increase ; so that provided the fibre is not inferior to the product obtained from established sources, there is good reason to expect a fairly ready sale. As a matter of fact, in the case of Sisal hemp, plantations already exist in the presidencies of Madras and Bombay, and in the province

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of Assam, and during the present year Indian Sisal hemp has realised 20*l*.-30*l*. per ton in London.

Turning now to the other aspect of sisal-hemp cultivation, *i.e.*, whether it is likely to form a profitable adjunct to tea-gardens, this is the subject of a pamphlet written by Messrs. H. F. Mann and J. Hunter, which has recently been issued by the Indian Tea Association. Mr. Mann is already well-known for his investigation into the causes of tea-blight, and Mr. Hunter is the manager of the Dauracherra Fibre Estate in Sylhet. It will not be superfluous, before passing on to the future prospects of this industry in the tea districts, to state some of the recognised facts concerning species of Agave in general, and those that have been introduced into India in particular. Agave and Furcraea are closely allied *genera* belonging to the order Amaryllidaceæ, and are both native to tropical America. Although the name "Aloe" has been popularly applied to varieties of Agave both in America and India, the agaves are entirely distinct from the true aloes, from which the well-known drug is obtained. Aloe is a genus associated with South Africa, and belongs to the order Liliaceæ. No species of Agave, therefore, is indigenous to India, but several have been introduced at different times. On referring to the literature of Sisal hemp, it will be observed that there has been a good deal of uncertainty about the different varieties which have been taken into cultivation, but the view is accepted that in Yucatan two varieties are grown, *Agave rigida* var. *longifolia*, known as Henequen blanco or *Sacci*, and *Agave rigida* var. *sisalana*, known as Henequen verde, or *Yaxci**; the latter is the variety which was introduced into the Bahamas, and is generally considered to yield the best fibre. The determination of the different species which are found in India is a matter of considerable difficulty. Dr. Prain, Director of the Botanical Survey, makes some remarks on this subject in his last report on the Royal Botanic Gardens, Calcutta: "The belief that all the Agaves naturalised in India belong to one or, at most, two species, *Agave americana* and *Agave vivipara*, would now also appear to be incorrect; it seems that, while, as a rule, more or less well-defined areas have particular species well established, the prevailing species in one area often differs from the most plentiful in another area. Moreover, it is found, when attempts are made to utilise the fibres of these local agaves, that somewhat diverse results are obtained; at times the fibre extracted is reported to be nearly up to the standard of Sisal, at other times it proves too weak to be worth extracting." "It is too soon yet to say how many

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* Information as to the Sisal Hemp Industry in Mexico will be found in the Bulletin of the Imperial Institute, No. I., p. 201.

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different Agaves have really become naturalised; by what characters they may be most certainly distinguished, or which of them are best for fibre-producing purposes, but sufficient information has already been obtained to show that considerable caution must be exercised by those desirous of laying down extensive plantations of local Agaves."

Apart from the flowers which are produced during the final stage in the history of the plant, the leaf furnishes characters which are useful for distinguishing between allied species; shape and proportion of the leaf, transverse sections at corresponding points, bloom and colour, form and position of the thorns, all furnish data which should enable a correct distinction to be made between species and between varieties. But the fact must not be overlooked that in the case of the Agave, cultivation under different conditions produces great changes in one and the same species. Considerable importance attaches to the methods of propagation of these plants. Although the plant expends so much energy in the production of the inflorescence, or "pole," the flowers very rarely set seed; but after the flowers have fallen, before the "pole" dries off, small buds giving rise to "bulbils" develop at the ends of the branches, close to the scar left where the flower has fallen away. These bulbils, after they have attained a certain size, can be planted out. Another vegetative method of reproduction is by means of small plants, "suckers," which develop upon the roots during the second or third year after planting, and continue to form for one or two succeeding years. "Suckers" are generally preferred to "bulbils," because the latter are produced at a time when the plant should be exhausted, but no definite experimental proof of their superiority has been adduced. Owing to the difficulty in obtaining plants, because the growers in the Bahamas and Mexico are not anxious to supply possible future rivals, the planters in India will, at present, at any rate, be compelled to make use of bulbils, which are produced to the number of one to four thousand on a pole. These, and where obtainable, the suckers, should be set out in nurseries, in well-prepared soil 6 in. or 8 in. apart, and without any cover or shade unless violent rain is expected.

It has not been determined how far the composition of the soil affects the growth of Sisal plants; the fact that these plants are indigenous to Yucatan, where the soil is underlaid with limestone rock, combined with the success that has attended the cultivation on the coral islands of the Bahamas, has given rise to the impression that Sisal hemp requires a calcareous soil, but there is evidence from the Hawaiian Islands that the quality of fibre is not inferior where the soil is de-

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ficient in lime. Again, it is well known that the plants grow well in poor soils, and there is resaon to expect that in a rich soil less fibre would be produced, but careful experiments on these points, and on the advisability of manuring are much wanted. Good drainage is a matter of primary importance, as the plants are very sensitive to moisture at the roots, and rough, even rocky, ground is suitable as long as a fair depth of soil is available for each plant

The nature of the industry involves a considerable outlay at the start. The accessories of the plantation are a factory with engine and boiler, fibre-extracting machines, space for drying the fibre in the open, also for storing under cover during bad weather, apparatus for baling the fibre, and a plentiful supply of water. On the larger estates it is found economical to have a light railway for conveying the produce from one point to another. In choosing the site for a plantation all these arrangements will have to be considered, so that, although undulating land provides the best drainage, the requirements of transport prohibit the use of land which is very steep.

The preparation before planting consists in clearing the land and grubbing up the roots of bamboos and other plants. In planting out, the space allowed between the rows varies from 8 ft. to 12 ft., and in each row the plants are set 4 ft. to 6 ft. apart; the arrangement must depend upon the length to which the leaves grow, and as mature leaves grow to 5 ft., 10 ft. by 5 ft. would seem to be none too open, which gives 870 plants to the acre. Generally, three-year-old suckers or four-year-old bulbils from the nursery are used for planting out, or plants varying from 8 in. to 1 ft. high. The roots are slightly trimmed, and the plants must be carefully laid at the required distances in soil which has been previously loosened, care being taken to keep the plant erect, with the base of the leaves clear of the soil.

After three years the plants grown from healthy suckers will yield leaves fit for cutting; a few of the largest may be cut in that year, 10 to 15 in the following year, after which the plant will continue to give 24–30 leaves per year. These are taken in three cuttings between October and June. The leaves are about 3 ft. long in the first cutting year, and increase about 6 in. in length each year until the full length is attained. The weight of the mature leaves cut on the Dauracherra Estate averaged 1,500 lb. per 1,000 leaves, and these produced 50 to 60 lb. of marketable fibre. Reckoning 1,000 plants per acre and 25 leaves to each plant, the amount of the fibre produced per acre would be from 1,250 to 1,500 lb., or taking an average,

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12 cwt. per acre, which is somewhat higher than the half ton per acre yield which is often taken as a basis for calculation.

The age at which the Agave produces its pole or inflorescence, and dies, has a considerable bearing on the estimation of the output, because even if a two-year-old sucker is planted at once, to take the place of the flowering plant, it does not give the full quota of leaves for the next two years In Yucatan the average life of the Sisal hemp plant is reckoned at 15 years, and at 10 years in the Bahamas ; some plants on the Dauracherra Estate poled at the ages of 10 or 12 years, but others were later in flowering. The factors which influence early and late polling are not at present understood ; in experiments made at Allynugger, Sylhet, the application of manure had the effect of hastening the polling stage, which suggests that the soil is a determining factor ; again, it has been observed that two plants taken from the same source do not necessarily flower at the same time, the cause for which may be attributed to the individual tendency of each plant or to localised variations in the conditions ; the problem is an important one, awaiting the investigator, who may find that by a process of selection it is possible to produce a long-lived strain.

Several cleaning machines have been produced which give good results. In the earlier machines based upon the original "raspador," the leaves were held in position by the manipulator while a revolving wheel provided with strips of brass or beaters removed the pulp from half the leaf ; by reversing the leaf the other half was cleaned.

Improvements on these machines were produced by the device of removable frames provided with automatic feed, and taking a number of leaves ; but the frames require to be filled by hand. This is the type of the Suter machine which was designed in India, and is now in use at the Agave Fibre Company's garden at Powai Kurla, Bombay ; this machine, like others of the same kind, has arrangements for pumping water over the leaves during the stripping process. The principles of the machines made by Lehmann, of Manchester, and Death's Fibre Machine Company, of Leicester, are similar to the Suter. A Suter's machine that costs 230*l.* in India (including cleaning and crushing apparatus) requires an engine of 5 h.p., and takes 3,000 gallons of water a day, and is said to clean 3,000 leaves per hour. The work of a Lehmann machine costing 65*l.* in London, using a 2 h.p. engine, is estimated at 10,000 leaves per day, but the manufacturers recommend the use of a preliminary crushing machine. A 5 h.p. Death machine, costing 140*l.*, and calculated to produce 4 cwt. to 6 cwt. of fibre per day, gave at Dauracherra only an output of 2 cwt., *i.e.*, the equivalent of 4,500 leaves per day.

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Automatic machines differ from those previously described, in the arrangement for feeding the leaves, which are presented sideways to the holding apparatus. Of these, the Todd machine has found great favour in the Bahamas. The leaves are gripped near the centre between belts and presented to the first scraping wheel, after which, by means of a special device, they are caught by the second series of holding belts so that the other half of the leaf is cleaned by a second scraper. The Torruella machine is similar to the Todd in general principle, but the leaves are fed on to rotating tables and are gripped by an eccentrically-pivoted cone which holds the leaves while they pass over the scutching wheels. A Torruella machine costing 600*l.* has been installed at the Dauracherra Estates; it requires four men to look after it, takes 15 h.p., and produces 5,000 to 6,000 lb. of cleaned fibre per diem.

It is most important that the fibre should be extracted as soon as possible after cutting, as the natural moisture is useful in cleaning, and exposure of the cut surface soon sets up fermentation which leads to discolouration. In India it is recommended also to rinse the fibre, even if the leaves have been washed during the scutching process, in order to insure the fibre remaining white. The fibre is dried in the open, but must be placed under cover during the night, or in the event of rain. After drying, the fibre is put up into bales weighing about 400 lb. The fibre is extensively used in America for binder twine and general cordage, and is sometimes mixed with Manila hemp; there is less demand for Sisal hemp in the United Kingdom.

The question finally remains, whether sisal fibre promises to furnish a profitable industry in tea districts, and how far the labour required for cultivation works in with the labour required on the tea plantations. The primary outlay for planting, for the factory, machinery, and means of transport, is considerable, and it is estimated to be not much less than that for a tea plantation. The land has to be cleared to the same extent as for tea, and during the first two years the cultivation requires regular labour, but after that period the labour can be reduced, and as the season for cutting the Sisal alternates partially with the busy season on the tea estates, the combination of the two undertakings in the same vicinity presents some advantages.

The cost of equipping a factory to deal with a plantation of 1,000 acres is estimated at 3,000*l.*, and the cost per acre for preparing the fibre and delivery in Calcutta at 7*l.* per acre; reckoning two-thirds of a ton of fibre per acre, this amounts to between 10*l.* and 12*l.* per ton. The Agave Fibre Company, on the basis

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of an outturn of 1,000 tons per annum, place the cost at about 14*l.* per ton in Europe, including insurance, freight, and broker's charges, together estimated at 3*l.* 8*s.* per ton, so that the estimates practically agree.

The price for Sisal hemp this year in the English market has varied between 20*l.* and 30*l.* per ton, as compared with 32*l.* and 34*l.* per ton in 1903.

ARTIFICIAL SILK.

Within the last 20 years threads exhibiting a close superficial resemblance to those of natural silk have been artificially produced, and have to some extent successfully replaced this material, either partially or wholly, in some classes of textile fabrics.

The term "artificial silk" applied to such threads or fibres is somewhat misleading, since it implies that they present a precisely similar appearance, and have a chemical composition identical with that of natural silk. The resemblance, however, is confined to their appearance, their chemical composition being entirely different. For this reason the names "*imitation silk*," or "*lustra-cellulose*," as proposed by Messrs. Cross and Bevan, would be more appropriate. Much useful information upon this subject is given in a paper by J. Merrit Matthews, in the *Journal of the Society of Chemical Industry*, February, 1904, p. 176, and also in the same author's work, "Textile Fibres," Philadelphia, August, 1904.

The first patent relating to the manufacture of "artificial silks" is that taken out by de Chardonnet in 1885, in which "pyroxylin" is used. Fibres produced by this process did not, however, appear on the market until several years later. Since de Chardonnet's first patent was granted many others have been taken out, but all are either modifications of his original process, or are methods for utilising some other material than pyroxylin. Cellulose in one or other of its forms (cotton, wood-pulp, ramie fibre, &c.) is the raw material in all cases except the "gelatin silks," which, however, do not appear to be of commercial importance. Of these forms of cellulose, wood-pulp seems to be the most convenient, since, owing to its fine state of division, it is readily acted upon by the reagents employed.

The methods of manufacture of the principal classes of "artificial silks" may be briefly described as follows:—

1. The "pyroxylin" method, in which a solution of nitrates of cellulose in a mixture of ether and alcohol is used.

Artificial Silk.

2. The methods in which cellulose dissolved in an ammoniacal-copper or zinc chloride solution is employed.

3. The "viscose" method, in which use is made of the solution obtained by treating cellulose with caustic soda and carbon disulphide. This solution is known technically as "viscose," owing to its curiously viscous character.

4. The "gelatine" method, in which filaments of ordinary gelatine are rendered insoluble by treatment with formaldehyde.

The crude material having been converted into a suitable state for manipulation by one of the foregoing processes is then subjected to mechanical treatment to convert it into fibres. As an indication of how this is done, the following description of the method used with pyroxylin may be given. The pyroxylin consists of a complex mixture of cellulose nitrates, the nature of the predominating constituent depending on the relative proportion of sulphuric to nitric acid employed for "nitration" and on the temperature and time of the reaction. The relative proportions of the acids and the conditions of time and temperature are varied according to the requirements of the manufacturer, *e.g.*, in the Chardonnet process 8¾ lb of cellulose are treated for from four to six hours with about 7¾ gallons of a mixture of 15 parts of fuming nitric acid (specific gravity 1·52) with 85 parts of sulphuric acid. When the fibres on microscopic examination appear to be completely nitrated the acid is removed by hydraulic pressure and recovered for further use, the resulting "pyroxylin" being thoroughly washed with water for several hours and then pressed until it retains a certain percentage of moisture. The latter is said to have an important influence upon the ease with which the pyroxylin is dissolved. This product is then dissolved in a mixture of ether and alcohol (other solvents are used in some of the processes), the solution is filtered from particles of undissolved fibres, which would cause "breaks" in the filaments in the next step of the manufacture. The clear solution is known as "collodion," and is a nearly colourless, highly viscous liquid. This collodion is forced under pressure through fine capillary jets. As it emerges from the jets it is coagulated by the rapid evaporation of the solvents, which are recovered by means of a hood and condenser on the machine employed, or, as in Lehner's process, by passing the filaments through a bath containing water, turpentine or other liquids.

Several of the fine filaments so produced are spun into one thread; other fibres, such as cotton or natural silk, being sometimes introduced to increase the strength of the thread. The latter is then wound on to spools in the same way as natural silk. It is, however, still useless for the manufacture of textile

Artificial Silk.

materials owing to its inflammability, and to reduce this it is "de-nitrated" by treatment with some reagent, such as ammonium sulphide, which regenerates the cellulose and leaves the thread in a form not more inflammable than natural silk.

If necessary the threads can now be bleached by the ordinary methods. The modes of working with "viscose," or cellulose dissolved in ammoniacal-copper reagents are similar to the foregoing, and only differ in the nature of the reagents used for coagulating the material and the absence of necessity for "denitrating" the threads. Of the methods alluded to, the "pyroxylin" and "viscose" methods alone are commercially important, those methods in which "gelatin" or "solutions of cellulose in ammoniacal copper reagents" are employed do not appear to have been worked on a commercial scale so far.

The physical properties of artificial silks produced by these various processes are very similar. They possess a fine but rather metallic lustre, which is said to be superior to that of natural silk, but a comparison of their properties with those of natural silk shows them to be inferior. The elasticity and tenacity, especially when wetted, are on the whole, lower than those of silk, as shown by the following table:—

BREAKING STRESSES IN KILOGRAMS PER SQUARE MILLIMETRE.

Natural silks.	Dry.	Wet.
Chinese	53·2	46·7
French, raw	50·4	40·9
French, boiled off	25·5	13·6
Artificial silks.	Dry.	Wet.
De Chardonnet's "collodion," undyed	14·7	1·7
Lehner's "collodion," undyed	17·1	4·3
Viscose (early samples)	11·4	3·5
Viscose (latest samples)	21·5	—
Cotton yarn (for comparison)	11·5	18·6

These artificial silks can be used for a great variety of purposes, and are extensively employed for the manufacture of fancy braids and trimmings and for numerous articles classed as "passementerie." When woven with cotton or natural silk, materials suitable for scarves, cravats, &c., can be manufactured, and for certain upholstery materials where great lustre is an advantage they are particularly suitable. They dye well, but as they weaken considerably when wet, especially when the liquid contains alkaline substances, great care must be taken in the dyeing process.

The most serious drawbacks to their more extended use are their weakness, low elasticity, and inability to stand repeated cleansing. It is stated that the cost of "pyroxylin" silk is about one-half that of natural silk.

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Artificial Silk.

Trustworthy statistics* as to the production of "artificial silk" are somewhat difficult to obtain. The de Chardonnet process is worked at Besançon (France), and other "pyroxylin" silks are stated to be produced at Spreitenbach and Zurich (Switzerland), Wolston (England), and Elberfeld (Germany). "Viscose" silk is manufactured at Lansdown, near Philadelphia, U.S.A., about 300 lb. per day being produced. A factory is also in existence near Stettin, which, in October, 1903, was turning out 50 lb. per day, and had a capacity for 2,000 lb. per day. The trade statistics published by the Government of the United States show that artificial silk fibre to the value of 170,000 dollars was imported into that country during the year ending June 30th, 1902, and that for the succeeding year the value of the imports of this article had increased to 434,033 dollars.

AGRICULTURE IN THE SEYCHELLES.

Until comparatively recently the Seychelles have been largely dependent upon one agricultural industry, viz., the cultivation of vanilla, but with the great increase in the production of this spice in other countries which has taken place in recent years, coupled with the severe competition of artificial vanillin, which can be successfully substituted for vanilla for a great variety of purposes, the period of prosperity for vanilla planters has waned, and the necessity of finding other products to cultivate has been keenly felt in the Seychelles.

In this connection the recently issued Colonial Report on these islands (No. 431), which gives much information regarding the present condition and future prospects of agriculture there, is of great interest, and from it and other sources of information the following particulars have been summarised:—

The staple food of the native population is rice, but this cannot be extensively grown owing to the mountainous nature of the country. The few swamps and marshes where this food-stuff was once cultivated have since been utilised for other products, and the whole of the rice now consumed in the island is obtained from India or Indo-China, the total quantity imported in the year 1903 being 2,276 tons.

The food-stuffs locally grown are manioc (cassava), cocoa-nuts and bread fruit. There is very little good pasture land, consequently cattle and sheep are very scarce, although pigs, which are fed largely on bread fruit, are numerous.

The food-stuffs imported during the year 1903 were valued at 395,679 rupees, of which nearly two-thirds was for rice.

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The following is a summary of the portion of the report dealing with the investigations conducted at the botanic station, with the object of improving the agricultural products at present cultivated or introducing new ones:—

The principal products now exported from the Seychelles are vanilla, cocoa-nut produce, cacao, guano and coffee. Although since 1901 the export of vanilla has decreased both in quantity and value, it is still by far the most important article of export. The decline of this industry during the last few years is due partly to the manufacture in Europe, on a commercial scale, of the synthetical substance vanillin, which is the principal flavouring agent of vanilla, and partly to overproduction of vanilla. (Compare *Imperial Institute Bulletin*, Vol. II., 1904, p. 30.) Notwithstanding the competition of the artificial article the demand for the natural product has not materially decreased, and consequently it is considered that vanilla culture in Seychelles need not be abandoned at present, since the planters' experience in its growth and preparation should enable them to compete with producers in other countries.

The varied products furnished by the cocoa-nut palm are important articles of export, so much so, that the future of the Colony is considered to depend in great measure on the development of this industry. The coast is fringed with palms, the flourishing condition of which bears evidence of the suitability of the soil to their cultivation. Many cocoa-nut plantations in several of the islands are at present suffering from what is termed locally "the disease." This is thought to be caused in the first place by a very small beetle (probably of the Scolytidæ family), followed by the invasion of beetles of the Longicorn and other families of coleoptera. It is noticeable that healthy trees suffer very little from the attacks of the insects, and it is only after years of cultivation that the ravages caused by the pests are noticed. It is suggested as a possible remedy that disease-resistant plants alone should be selected for propagation, and that the cultivation should be more carefully managed, especially as regards systematic manuring of the land. The total annual production of cocoa-nuts in Seychelles amounts to 13,000,000 nuts. The preparation of oil, "coprah," "poonac," desiccated cocoa-nut, and coir rope, yarn, or fibre, are remunerative industries which, if carried on with suitable machinery, would be capable of further development. The area at present under cocoa-nut cultivation in the Colony could, if necessary, be considerably increased, and it is thought

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that in this manner the loss sustained by the cheapening of vanilla could best be counteracted.

Cacao cultivation in Seychelles has been largely abandoned owing to the prevalence of disease amongst the plants. Experiments have shown that the "Forastero cacao" introduced from Ceylon grows well, and withstands "canker" much better than the Caracas cacao originally cultivated in the islands. The "canker" disease is kept under control in Ceylon by simply clearing away shade trees as much as possible and excising the bark of trees which have been attacked. The diseased tissue is burnt or buried with quicklime, and the trees are treated with "Bordeaux mixture" with a view to checking the spread of the disease. The cultivation of Forastero cacao in Seychelles should lead to the revival of this remunerative industry, since the climatic conditions are known to be favourable.

The guano found in several of the islands is known to be a rich phosphatic manure. It is not exported to any extent, and even local planters, as a general rule, do not make use of it on their plantations, since they are, as a class, ignorant of the value of this material as a fertilising agent.

Although the climate and soil of the Seychelles are well suited to the cultivation of coffee, and the Liberian variety is very abundant, yet some coffee, mostly of a low grade, is imported from India and Aden. The coffee disease prevalent in the Colony does not affect the Liberian variety, and it can be checked on the Arabian kind by the periodical use of Bordeaux mixture. The development of this industry is an important matter for consideration.

The re-afforestation of much of the waste land in the Seychelles is a subject which is also receiving attention, and experiments are in progress with this end in view. The Seychelles cedar (*Casuarina equisetifolia*) and some varieties of eucalyptus are very promising for this purpose, whilst other valuable timber trees such as the Seychelles and Ceylon "iron woods" (*Vateria*), "Takamaka," (*Callophyllum*), *Heritiera*, "Indian lilac" (*Melia*), teak, &c., are also making excellent growth.

As the Crown lands are situated at different elevations, experiments are being conducted on these with a number of newly-introduced plants. Among these are cardamon, camphor, castilloa rubber, eucalyptus species, fir trees, and Java almond.

The Seychelles iron-wood tree (*Northea seychellana*) which grows to a height of over 50 ft., provides a valuable timber for building purposes and for making small waterproof vessels. This tree is also interesting on account of the latex which flows from it when tapped. The following table shows the quantity

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of latex which exuded on a rainy day from a number of young trees:—

Number.	Diameter in inches.	Number of wounds.	Quantity of latex. Cubic Centimetres.
1	5	1	5
2	10	1	10
3	8	1	40
4	8	1	25
5	10	1	20
6	5	1	15
7	6	1	10
8	10	1	25
9	10	1	55
10	5	1	15
11	6	2	30
12	7	1	40
13	5	1	15
14	8	1	70
15	5	1	10
16	11	5	85
17	8	1	15
18	12	2	75

A specimen of the coagulated latex has been examined in the Scientific and Technical Department of the Imperial Institute to ascertain whether it had any of the properties of rubber or gutta-percha. The results showed that the material was of no commercial value.

There are several edible fruits well adapted to the climate and soil of the Seychelles. Except in the outlying islands, where the arable soil is more or less mixed with deposits of guano, there is not much room left in the Colony for the cultivation of herbaceous plants, which as a rule require good soil and much manure during the short time of their growth. In the principal islands, where the soil has been exhausted already, it is only possible to cultivate those herbaceous plants which are not benefited by large quantities of manure.

The pineapple seems to be well adapted to these special agricultural conditions, its successful cultivation being, as a rule, more dependent on climatic conditions than on the soil and its treatment. Amongst the wild and cultivated varieties of pine available in the islands, only one is considered suitable for export purposes. This variety is known locally as "Anana Maingard," it compares favourably with the West Indian "smooth Cayenne." Several varieties have been introduced from the West Indies, Ceylon, Penang, Mauritius and Singapore, and the most successful of these are available for cultivation this year.

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Owing to the geographical position of the Seychelles the pineapples produced will meet with little competition on the London market during the principal fruiting season, which lasts from November to January.

Many attempts have been made to export oranges from Seychelles to Mauritius or to Aden. The fruit intended for export should be picked three or four days before packing, and laid out in single layers so as to enable the surface moisture to evaporate. This treatment preserves the good appearance and hardens the rind, which is then better able to resist the attacks of insects. It is pointed out that the oranges of Seychelles may be greatly improved by devoting more attention to their cultivation. The manuring of the trees is considered especially important, it being necessary to supply each tree with a complete fertiliser each year, such as the following:—

Nitrate of soda	1·53	kilograms.
Superphosphate	1·23	„
Chloride of potassium	0·246	„
Sulphate of lime	1·025	„
Sulphate of iron	0·410	„

Amongst other fruits suitable for cultivation in Seychelles, limes and bananas are suggested.

In the Colonial Report (No. 22), issued in 1903, Mr. R. Dupont, Curator of the Botanic Station, Seychelles, drew attention to the importance of Para rubber, and the advisability of attempting its cultivation in the Seychelles. In the present report it is interesting to note that a large number of Para rubber plants has been introduced into the Colony and that these are making excellent progress, the climatic conditions evidently being favourable to them. There are in the islands a number of marshy places which hitherto have been left uncultivated, and it is in these places that the Para rubber tree has been found to grow most successfully.

The method of cultivating cotton is well known in the Colony, and considering the interest now attaching to this important product it is hoped that its cultivation will be revived and meet with better financial results than hitherto. Two samples of cotton grown in the Seychelles are at present under examination in the Scientific and Technical Department of the Imperial Institute.

Ramie is another fibre which it is thought might be grown with success in the guano islands. At present, however, the cultivation of this plant is only in the experimental stage.

The "kapok" plant grows wild, but the low price of this product scarcely warrants its cultivation.

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Besides the products already referred to, several others are noted in the report, some of which have been long established in the Colony. The spices, nutmeg, cinnamon, and pepper, thrive well on soils which are not well adapted to most other products. Further, citronella and lemon grasses, introduced from Ceylon, have been shown to grow well. The oils obtained from these grasses are increasing in value, and the cultivation of these plants, it is suggested, might prove a profitable undertaking.

THE PRODUCTION OF TANNING MATERIALS.

Considerable attention is at the present time being given, in German East Africa, to the initiation of what may be called minor agricultural industries. In this work a prominent part is played by the Biological Agricultural Institute, situated at Amani, which not only places expert advice at the disposal of planters in this German Colony, but also carries on agricultural investigations on products already cultivated or suitable for cultivation there. The Institute issues from time to time leaflets giving information on economic plants suitable for introduction into German East Africa. One of these recently published, deals with a number of tanning materials which are considered likely to grow well in the Colony. In the following paragraphs a *résumé* of the information contained in this leaflet is given, which may be of interest to planters in the tropical and sub-tropical colonies and dependencies of the British Empire where the plants might be grown.

RHUS SPECIES.

Of these plants, *Rhus coriaria*, yielding the well-known tanning material, sumach, grown in Sicily, Spain, Portugal, Greece and Cyprus, is one of the most important. It has been introduced into Algeria and some parts of Australia, and would probably grow well in East Africa. The plant grows to great advantage on sunny slopes of dry, stony and barren soil ; when grown on rich soil the product is deficient in tannin. The plants, which may be grown from seed, develop rapidly, and in the second year are ready for cropping. The leaves are separated from the twigs, dried quickly in the sun, ground to powder, and packed for export. After about 15 years' growth the shrubs cease to yield leaves rich in tannin and must be replaced by new plants. The tannin content of sumach leaves

The Production of Tanning Materials.

varies from 23-2[illegible] per cent, and occasionally reaches 30 per cent Owing to its freedom from objectionable colouring matters and its mild and soft tannage, sumach is much used for tanning fine leathers for binding books, and these have the advantage that exposure to gas fumes and sunlight has but little destructive effect on them It is probable that a regular supply of good sumach from a new source would be welcomed, since much of that now placed on the market is regarded with suspicion because of the extensive adulteration practised

Rhus semialata—This plant grows freely in the Himalayas and in Assam, but is indigenous to Japan and China The galls produced on this variety of sumach contain from 60–70 per cent of tannin • These constitute an important source of gallotannic acid now chiefly obtained from the galls of the gall-oak, *Quercus infectoria*, found in Asia Minor

Rhus vernicifera and *Rhus succedanea*—These species are indigenous to Japan, and are widely distributed in other subtropical and temperate countries The cultivation of the former species has been tried on a small scale at Saharanpur, in India, but with little success, and it is somewhat doubtful whether either could be acclimatised in East Africa The former yields the valuable Japan lacquer, and the latter, although producing a somewhat similar substance, is cultivated for the sake of its wax known in commerce as "Japan wax," which is obtained by hot expression of the seeds The leaves of both varieties contain a small quantity of tannin similar to that yielded by sumach

Rumex hymenosepalus—This plant yields the valuable tanning material commonly known as "Canaigre," or "tanner's dock" It is indigenous to the southern portions of the United States and to Cuba The species has been introduced into Madagascar and Algeria and would probably be successful in suitable parts of East Africa The plants require a light sandy, alluvial soil, and a heavy rainfall or adequate irrigation The seeds are planted in May and the young shoots transplanted in October, during the rainy season they grow rapidly, and attain maturity in April In the succeeding May the plants die down, but the roots, which constitute the tanning material, are not harvested till some months later When gathered they are sliced into thin pieces, rapidly dried at 60° C, and exported in this form, or a canaigre extract is made by exhausting the ground or sliced roots with water at a temperature of 56° C This solution is then carefully evaporated in vacuum pans and the resulting semi-solid mass finally dried at the same temperature The extract so prepared is quite soluble in water, and contains about 75 per cent of tannin The dried roots contain on the average between 26 and 38 per cent of tannin, depending on

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the conditions under which they have been grown. The yield of dried root varies from 10 to 20 tons per acre, and is principally influenced in favourable directions by a good rainfall or systematic irrigation. Canaigre gives a bright orange-coloured leather, of good weight and toughness ; it is particularly suitable for light leathers for harness.

Cæsalpinia coriaria.—The pods of this tree, which is indigenous to Central America, and is now cultivated in Java, India, and Australia, constitute the valuable tanning material, "divi-divi." The tree, which yields a profitable crop until it is about 25 years of age, requires a fairly dry, light soil, and does best at an altitude of from 1,500 to 2,000 feet. It readily grows from seed ; the young shoots are generally transplanted after about six months, and in the fifth or sixth year commence to bear a fair quantity of "fruit," the husks of which constitute the tanning material. In preparing the material for the market the pods are broken up, the husks dried in the sun, and the black seeds, which are liable to cause fermentation of the tanning liquor, removed. The American divi-divi pods are said to yield from 30 to 50 per cent. of tannin, those from India usually contain about 30 per cent. (compare *Imperial Institute Bulletin*, 1904, Vol. II., No. 2, p. 92.)

It is proposed to cultivate this tree on parts of the sea coast of German East Africa where the altitude and soil are suitable. "Divi-divi" yields a medium, light coloured, fairly heavy and firm leather, but the extent to which it can be used is limited by the liability to fermentation of tanning liquors prepared from it. This tendency, for example, is stated to seriously interfere with its use in India.

UTILISATION OF MANGROVE BARK IN QUEENSLAND.

The mangrove swamps which fringe the coast-line of most tropical and sub-tropical countries were formerly exploited almost solely for the production of fire-wood, but in recent years an enormous demand has sprung up, especially in continental Europe, for the barks of certain species of mangroves. This material is employed as a tanning agent for the production of low-grade leather. The amount of tannin contained in these barks varies within wide limits, but in some cases is as high as 50 per cent., and usually does not fall below 30 per cent. The

Utilisation of Mangrove Bark in Queensland

principal centres of production so far have been the various European settlements along the east coast of Africa, Borneo, Java, and, to an unimportant extent, in India. The bark is either exported as such, or is converted into "mangrove cutch" by extraction with water and evaporation of the infusion so obtained until a solid extract is produced. Mangrove bark and extract have the disadvantage of communicating to leather tanned with them a disagreeable red colour to which exception is taken by many leather buyers; for this reason this tanning material has, so far, not found favour with tanners in this country, but there are indications that it is beginning to come into use possibly because various more or less satisfactory methods of obviating the coloration of the leather are now available.

Recently, as the result of experiments carried out by the Queensland Department of Agriculture, attention has been directed to the possibility of exploiting the mangrove trees which grow profusely along the North-east coast line of that Colony. The local tanning industry is fairly extensive, as is shown by the fact that about 2,500 tons of wattle bark, the principal Australian tanning matterial, valued at 20,000*l*., are annually imported into Queensland from Tasmania, New Zealand and South Australia.

Comparisons of the mangrove bark obtainable in the Colony, with the imported wattle barks, have been made by the Department of Agriculture, and the results which are summarised in the following table show that the Queensland bark is much richer in tannin than the imported material:—

—	Mangrove from—	Wattle barks imported into Queensland from—		
	Cairns.	Tasmania.	New Zealand.	South Australia.
Moisture	9·35	10·34	9·53	9·46
Total ash	4·78	2·67	2·47	3·33
Soluble ash	1·70	0·96	0·84	1·64
Resinous matters, &c	0·75	1·40	0·61	1·80
Total extractive matters	47·90	40·48	39·80	42·40
Tannin	39·50	29·60	27·65	31·25
Non-tannin extractive matter ...	6·70	9·92	11·96	10·51

At first, concessions to strip and utilise this bark were refused, mainly on the ground that the removal of the trees which grow almost wholly on lands between high and low water marks, would lend to greatly increased erosion of the foreshores, with the result that silt and mud removed by the scour would settle in the river mouths and harb[illegible]d necessitate dredging.

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Utilisation of Mangrove Bark in Queensland.

As the result of careful consideration of the problems involved, a code of regulations was eventually drawn up to meet these difficulties, and in 1903 a first concession to strip mangrove bark was granted from the coast-line between Halifax Bay and the Johnstone River, a distance of about 150 miles. Later, a further concession was made, covering the coast-line from the Johnstone River to Double Island, north of Cairns.

In return for the sole right to strip bark in the conceded areas a royalty of 5s. per ton of bark collected is charged. The regulations require that the exploitation be carried on continuously, and that a strip of mangroves one chain (66 ft.) wide be reserved along the foreshore of all harbours, rivers and creeks.

Since the first two concessions referred to above were granted applications for other areas have been received and favourably considered, and it is probable that within the next few years the whole of the coast line from the 25th parallel (Hervey Bay and Great Sandy Island) northwards to the 13th parallel at Princess Charlotte Bay will be opened up for the production of bark. Although much of the bark will doubtless be used locally the possibilities of creating an export trade from so large an area are great, and already sample consignments have been sent to Germany and have been favourably received there. The cost of collecting and preparing the bark for the market is small, and it is considered that Queensland is in a position to compete, under favourable conditions, with many of the principal sources of supply of these and similar barks.

THE MINING AND PREPARATION OF MICA FOR COMMERCIAL PURPOSES.

1.—General Characters of Mica.

Owing to the increasing use of mica for various industrial purposes, numerous enquiries respecting its mining and preparation have been received at the Imperial Institute both from commercial firms in this country and from producers in the Colonies. It has been thought desirable, therefore, to prepare the present notice for general information on the subject.

The term mica includes a number of allied mineral substances, which are characterised by great fissility—laminæ of only one hundred-thousandth of an inch being procurable from some varieties. Mica has a hardness of from two to three in the ordinary mineralogical scale, and is, as a rule, highly flexible and elastic in thin films. It is usually transparent, when in

The Mining and Preparation of Mica for Commercial Purposes.

thin plates, and like other transparent substances, is a bad conductor of heat and electricity.

2.—SPECIES OF MICA.

Mica varies considerably in chemical composition and physical characters. The principal species of commercial importance are the following:—

(1) *Muscovite,* or potash-alumina-mica.—Typical analyses give the following as the percentage composition of this species:—

		Per cent.	Average. Per cent.
Silica	SiO_2	45 to 47	46
Alumina	Al_2O_3	30 to 37	33·5
Ferric oxide	Fe_2O_3	0·5 to 5	2·7
Ferrous oxide	FeO	0·5 to 2	1·2
Magnesia	MgO	0 to 2	1·0
Potash	K_2O	8 to 11	9·5
Soda	Na_2O	0 to 2	1·0
Water	H_2O	4 to 6	5·0
Fluorine	F	0 to 1	0·5

If the percentage of iron rises above five, muscovite becomes distinctly tinted when plates thicker than 0·5 millimetre (0·02 in.) are viewed by transmitted light. The colour varies through pale brown, red and yellow, to green, according to the proportion of ferric and ferrous oxide present. The best mica of Bengal shows a deep ruby tint in plates half an inch thick, whilst Nellore mica usually exhibits a greenish colour. Occasionally a deep green tint is shown, as in Chinese mica, due to the presence of an alkaline manganate.

The lustre of muscovite varies from vitreous to pearly, and the hardness from 2 to 2·5.

(2) *Phlogopite,* or magnesia mica, has usually a percentage composition within the following limits:—

		Range Per cent.	Average Per cent.
Silica	SiO_2	39 to 44	41·5
Alumina	Al_2O_3	13 to 15	14·0
Ferric oxide	Fe_2O_3	0 to 2	1·0
Ferrous oxide	FeO	0 to 1·5	0·7
Magnesia	MgO	26 to 29	27·5
Potash	K_2O	8 to 10	9·0
Soda	Na_2O	0·4 to 2	1·2
Water	H_2O	1 to 5	3·0
Fluorine	F	1 to 5	3·0

It is less elastic than muscovite, and less liable to crack transversely to the plane of cleavage. Offering, as it does, a greater electrical resistance, it is of greater value as an insulator. As a rule, phlogopite is coloured more deeply than muscovite, by the presence of the same proportion of iron oxides. When the total amount of the ferrous and ferric compounds exceeds 5 per cent., a plate only 0·1 mm. thick is distinctly tinted. If ferrous oxide is mainly present, the colour is bottle-green, while if the percentage of ferric oxide is the greater the mica is red or yellow, the shade being usually darker than that produced by a corresponding amount of ferrous oxide. When the percentage of iron is under 2, and over 0·05, the phlogopite shows a pale yellow in a thickness of 0·1 to 0·5 millimetres ; the colour passing to an amber shade with thicker plates. This is known as amber mica, and is regarded as especially valuable for insulating purposes. It may be remarked that the insulating quality of mica containing a small percentage of ferric oxide is said to be greater than that with a similar amount of ferrous oxide. The silver amber mica from Brazil is a phlogopite, which is rendered opaque by the inclusion of films of air or other gases. It is a valuable insulator, except where it is penetrated by cracks, through which ferruginous water has entered and modified the surrounding mica—changing the colour to a deep brown, and at the same time rendering it transparent. Chemical analysis of such altered mica shows that the amount of silica, magnesia and potash has been diminished, and that of the combined water and ferric oxide increased; whilst at the same time the gases forming the films appear to have been absorbed by the additional water present. Probably similar changes take place in the hydration of other micas. The hardness and elasticity are diminished in such hydrated micas.

The lustre of phlogopite varies from pearly to sub-metallic, and the hardness from 2·5 to 3. When the total percentage of iron oxides amounts to 3·5 per cent. the mica may be considered on the border line between phlogopite and biotite.

Biotite, or iron-magnesia-alumina-mica, varies between somewhat wide limits in its chemical composition, as the following table shows:—

		Range Per cent.	Average Per cent.
Silica ...	SiO_2 ...	37 to 41 ...	39
Titanium oxide	TiO_2 ...	0 to 2 ...	1·0
Alumina ...	Al_2O_3 ...	14 to 18 ...	16
Ferric oxide..	Fe_2O_3 ...	2 to 8 ...	5
Ferrous oxide	FeO ...	4 to 20 ...	12
Magnesia ...	MgO ...	1 to 24 ...	12·5
Potash ...	K_2O ...	7·5 to 10 ...	8·8
Soda ...	Na_2O ...	0 to 1·5 ...	0·7
Water ...	H_2O ...	1 to 4·5 ...	2·8
Fluorine ...	F ...	trace to 2 ...	1·0

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Biotite is usually deep brown, green, or black, in plates of appreciable thickness, and in the more ferruginous varieties the thinnest laminæ may be dark green, blood red, or brown. The lustre is usually splendent, but is sometimes pearly, and in the case of black biotites, may be sub-metallic. Biotite is regarded as less suitable than the other varieties for insulating purposes.

Other varieties of mica are *lepidolite*, or lithia-mica, with from 1 to 6 per cent. of lithia; *paragonite*, or soda-mica; *zinnwaldite*, or lithia-iron-mica, containing from 3 to 5 per cent. of lithia, 9 to 12 per cent. of iron oxide, and 4 to 8 per cent. of fluorine; and *fuchsite*, or chromium-mica, which is deep green in colour, due to the presence of from 2 to 4 per cent. of chromium oxide. None of these, however, are of much value commercially. It is important to be able to distinguish phlogopite from muscovite. This is easily done with a polarising or petrological microscope of the simplest character. A plate should be peeled until it is as nearly as possible 0·25 millimetre (0·01 in.) in thickness. It should then be rotated between crossed nicols. A plate of muscovite, under these conditions, shows bright colours, whilst one of phlogopite, under similar circumstances, allows only a faint greyish-white light to pass.

MODE OF OCCURRENCE.

Mica is one of the most widely-distributed minerals, occurring, as it does, in the majority of igneous and metamorphic rocks, and in many of the products formed from their decomposition, but it is only in exceptionally favourable circumstances that it is found of a size and quality to be of much use for industrial purposes. Large plates of muscovite are almost entirely restricted to coarse granite veins, in which the principal constituents of the rock, quartz, felspar, and mica, are developed in crystals of exceptional size. This vein rock may be described as giant granite, pegmatoid granite, or, if it has the characteristic intergrowth of quartz and felspar, as granite-pegmatite or pegmatite. Pegmatoid granite is found in dykes or veins which are usually associated with great granite masses, and are regarded as the result of the consolidation of the last remaining liquid portion of the granite. The veins may either traverse the granite itself or the surrounding rocks to a considerable distance. In the former case they are never rich in mica, but when the adjoining rock is a member of the crystalline metamorphic series, especially mica schist, the conditions are much more favourable.

The following types have been definitely determined, as forming, in one place or another, the "country" (*i.e.*, the

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adjoining rocks), associated with the Indian mica-bearing pegmatoid-granites:—

Compact quartzite.
Coarse granular quartz rock, with muscovite scales.
Quartz biotite (mica) schists.
Quartz schists, with mica and kyanite.
" " fibrolite.
" " iron ore.
Fibrolite gneiss.
Chiastolite mica schists.
Quartz-epidote-gneiss.
Quartz-biotite-hornblende-rock, with large lumps of magnetite.
Epidiorite.
Hornblende-schist, with garnets.
Hornblende-schist, with scapolite.
Pyroxene granulite.
Granulite (leptynite).
Diopside gneiss, with sphene.
Anthophyllite rock.
Garnetiferous biotite gneiss (biotite granulite).
Chlorite schist.
Talc schist, and compact potstone.
Limestone and dolomite, with chondrodite.
Wollastonite, and tourmaline, ophicalcite, and ophidolomite.

There is reason to believe that some of the materials of the pegmatoid veins have been obtained from the rocks into which they have made their way, so that when the vein occurs in "country" consisting of rocks rich in biotite, or other minerals containing a large percentage of iron, one may expect to find the mica of the intrusive rock to be biotite, and when in "country" formed largely of talc schists, limestones rich in magnesia, dolomites or ophidolomites, the mica of the pegmatoid veins will probably approach phlogopite in composition. The mica occurs in irregular or six-sided crystals known as "books," from the facility with which they can be opened up into thin leaves. In some cases the hanging wall, in others the foot wall of the vein, contains the best mica, whilst in many instances the mica is distributed more or less uniformly through the whole width. As a general rule, the abundance of the mica varies from point to point along the length of the vein, and the richer portions are continued downwards, usually in an oblique direction, in what are known as "chutes," or "shoots."

Phlogopite and biotite comparatively rich in magnesia occur in Ceylon, not as one of the constituent minerals of a pegmatoid granite dyke, but in veins consisting mainly of mica, which sometimes occupy strike or dip faults, and at other times are parallel to the foliation of the rock, which is usually a "granulite" belonging to the charnockite series of T. H. Holland, including charnockites proper and other hypersthene rocks of different degrees of acidity. The veins rarely exceed 1 or 2 ft. in diameter, and are composed of crystals or "books" of mica, varying in size and thickness. They are inconstant in character, and pass irregularly into a fine-grained micaceous rock, or die out altogether. They sometimes branch, and veins parallel to the foliation may pass into others following joint planes. These mica veins are usuallly met with near the junctions of the granulites with crystalline limestones rich in

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magnesia, partly in the form of carbonates and partly in that of silicates. Sometimes the veins are found in the limestone itself, but in that case the mica plates are rarely large enough to be of commercial value. Phlogopite and biotite are also met with in Ceylon, in bands of pyroxene-mica-rock in granulite, as well as in zoned dykes, but these occurrences are of little commercial importance.

The mode of occurrence of the amber mica (phlogopite) of Canada appears to closely resemble that of Ceylon, and according to Bornhardt, muscovite occurs with similar associations at Suvi stream (Ssuwi Bach), near Mount Pongwe (Pongue Berg). It is not stated, however, that these specimens were either optically or chemically examined, and on more careful investigation they may prove to be phlogopite.

In many cases, however, where the chemical and mineral composition of the rocks are favourable, and have resulted in the formation of mica, subsequent changes have rendered it useless for commercial purposes. Any earth movements, except those of the slowest and most uniform character, which affect the rocks in which the mica occurs, will produce creases and cracks, which render it almost valueless; and, as there are few localities which have not, in the time which has elapsed since the original formation of the mineral, been at one time or other subjected to such movements, the occurrence of mica, free from flaws of this description, is quite exceptional. Mica at the surface is also liable to be crumpled by the creep of the soil or subsoil, under the influence of gravity. Again, rain and underground water, especially when charged with carbonic and other acids, or ferrous carbonate, have a very injurious effect on mica with which they come in contact, either at the surface or in the neighbourhood of cracks and fissures, such as often occur in veins associated with dip or strike joints.

THE USES OF MICA.

These depend mainly on its transparency, its comparative freedom from liability to injury by heat or shock, its extreme fissility, and its resistance to the passage of heat and electricity.

Formerly it was chiefly valued on account of its transparency, and it is still to some extent employed in place of glass where the use of the latter is difficult on account of its fragility, or its inability to stand a high temperature. Amongst applications of this nature which still survive may be mentioned the chimneys used with incandescent gas-burners, the windows of lanterns, and the peep-holes of furnaces. A number of very resistant glasses have, however, recently been put upon the market, and these tend to restrict the uses of mica in these directions.

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Mica is also used as a surface for painting, especially in India. It is specially adapted for lantern slides, being easily coloured with transparent pigments. It has been employed for covering photographs and pictures, and valuable historical documents, enclosed between two thin sheets of mica, may be studied without risk of injury from handling, being at the same time protected from the attacks of insects, and to some extent from fire. The use of mica envelopes has been suggested for similar purposes. Thin films of mica are also used to a slight extent in photography, as a substitute for glass plates and celluloid films, being lighter than glass, and, unlike celluloid, non-inflammable; they have the further advantage that the negative may be subsequently removed, with only a thin carrying film of mica. For mounting soft and collapsible natural history specimens for exhibition in spirit, thin sheets of mica are admirably adapted, and no convenient substitute can be found which will remain unaffected by the spirit and at the same time be transparent and soft enough to permit the free use of needle and thread for purposes of attachment. Passing reference may also be made to its use for preparing microscopic sections of small fossils or grains, and for various optical purposes.

White mica, broken into very small scales, is used to give a glistening appearance to toys, wall paper, and other objects, whilst the still finer material has been made the basis of a paint. It has been proposed to employ the green mica fuchsite in a similar way. It may be mentioned in passing that a compact variety of the same mineral was in ancient times used for carving.

The extreme facility with which mica is split up into thin films, and its strength and elasticity, enable it to be used in many cases where it is desirable to combine lightness with a certain amount of rigidity, as in the vanes of anemometers, used in testing the ventilation currents in mines. Thin films of mica, silvered and bent into the required shape, are also used as mirrors and reflectors in delicate physical apparatus.

There are numerous applications of mica depending mainly on its very low conductivity for heat, and for these the ground-up material is usually the most suitable, though cheap mica-waste (scrap mica) sometimes answers the purpose. The most important use of the mineral coming under this head is in the construction of non-conducting packings and jackets for boilers and steam pipes. The parallel disposition of the flakes, perpendicular to the direction in which the heat passes, materially increases its non-conducting quality. Mica has also the advantage that it will stand any abnormal heating* which would carbonise packing composed of any organic

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* Prolonged exposure to intense heat, will however destroy its elasticity.

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material, though in this respect it presents no advantage over asbestos. It does not disintegrate under vibration, and being comparatively soft, it will not, if accidentally included in a bearing, abrade it as would inorganic "wool" formed of slag or glass. It is practically free from moisture and acids, which attack iron and steel, and if moisture leaks in, the mineral is comparatively unaffected by it. Mica of inferior quality is cheap enough to be used as a non-conducting layer on the roof of a house, to keep out the heat in tropical countries. It is stated that a layer of mica-waste only a quarter of an-inch thick, under a tiled roof, makes a difference of 15° Fahrenheit in the temperature of the air immediately below the roof. Its employment has also been suggested in sun-hats and other articles of clothing, as well as for bedding.

The most important uses of mica at the present day, and those which absorb by far the greater part of the supply, depend upon its high electrical resistance, combined with its flexibility, and the fact that it is but little affected by sudden exposure to high temperatures. It is especially used between commutator segments in dynamos, alternators, and transformers. Strips up to 7 in. or 9 in. long are employed for this purpose, but for greater lengths whole strips are considered to be too expensive, and it is usual to build them up of shorter pieces placed in several layers, with a total thickness of 0·8 millimetre (0·03 in.), so as to break joint.

Thin plates of mica from 0·02 to 0·06 millimetre (0·0008 to 0·0024 of an in.) in thickness are also built up with an insulating cement, such as shellac, to form non-conducting sheets, on a foundation of longcloth or paper. In the manufacture of this material, which is known as micanite, cheap sizes of mica can be utilised, and the splitting up of the smaller plates into these films has become an important feature in the mica industry of India. If a suitable cement be employed these sheets can, on gentle heating, be bent or moulded to form a non-conducting covering to metallic objects in cases where the comparatively rough surface of the artificial product is not objectionable. It is especially used in the form of cylinders to protect shafts or soft iron cores of electrical machinery.

The insulating properties of micanite are stated to be superior, both in degree and uniformity, to those of ordinary mica. It can also be produced in a thinner form, known as micanite cloth, which is used for repairing electrical apparatus. By combining powdered mica with other ingredients such as sulphur and iron oxide, a material is obtained which is employed in the manufacture of insulators for the support of wires employed in the transmission of electricity.

Powdered mica has been used, in combination with graphite

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and grease, as a lubricant. Another application is its use, in the place of "Kieselguhr" (siliceous infusorial earth), as an absorbent of nitro-glycerine, the explosive thus formed being known as mica powder. It has been proposed to impregnate powdered mica with phenol (carbolic acid) for use as a disinfecting powder. A passing reference may also be made to the employment of waste mica as a manure for lightening heavy soils and producing a supply of potash.

There are therefore a large number of applications for which the special characters of mica pre-eminently recommend it, and it is difficult to believe that there will ever be found a satisfactory substitute for it.

THE MINING OF MICA.

The exploitation of mica deposits has hitherto usually been conducted on a small scale, and after a very desultory fashion, by persons without competent knowledge of systematic mining. Either open quarries have been excavated or an attempt has been made to follow the mineral downwards in irregular shafts and passages. But as the deposits occur in veins, either alone or associated with other substances, the most economical and satisfactory method of working them is to follow the same general lines, as in the case of metalliferous veins. The practice of sinking on the veins pursued in many localities causes a considerable destruction of valuable mica. A vertical shaft should be sunk, and cross-cuts driven, till the vein is reached. Levels should then be run along the strike of the vein, either in it or close under its foot wall, and the mineral should then be mined by overhead "stoping." In this way there is a clean and dry working face, in which the "books" of mica are readily detected and removed without damage. There is also a saving in the amount of dead-work, for the blasting is assisted by gravity, and in the case of the pegmatoid granite veins at least, the waste material, or "deads," is more than sufficient for stowing the worked-out excavations. An additional advantage is that the cost of hauling the deads to the surface is saved, and the necessary expenditure on timbering is much diminished. In any case it would be desirable, as Holland has suggested (*Memoirs of the Geological Survey of India*, 1902, Vol. 34, p. 40), to adopt some system of payment by results, like the "tribute" and "tutwork" in the Cornish metalliferous mines, and the "bargains" of the Welsh slate quarries, so that good mica should not be destroyed by ignorance or carelessness. For blasting purposes ordinary powder is best, as it injures the mica less than more powerful explosives, but even that should be dispensed with when the nature of the rock renders it possible, as in the case of "stoping" operations in some phlogopite mines in Canada,

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and in the decomposed pegmatoid granite veins of Brazil. As has been stated, mica near the surface is usually injured by the action of rainwater and movements of the soil or subsoil, so that at a little depth a better quality is usually obtained. Otherwise there seems no foundation for the common idea that the value of the mica increases with the depth. Flaws due to structural earth movements will be just as common at great depths, and the size or number of the "mica-books" bears no fixed relation to the distance below the surface.

THE DRESSING OR PREPARATION OF MICA FOR SALE.

The leading principle which should guide owners of mica mines in this matter is the preparation and classification of the mineral, so that a number of separate products, each uniform in character and quality, can be placed on the market. In most cases a large proportion of the mica brought to the surface has to be rejected. It is of the greatest importance not to mix inferior with better-class material, for a package of mica sells approximately at the price of its worst plates. Books or plates should, if necessary, be split* to remove damaged films or inclusions of foreign materials, and the plates themselves should be carefully trimmed. This may be done by a knife or a pair of shears, or else a special cutting-table or "guillotine" may be employed, which has a long curved knife, working up and down on a pivot, at the edge of a solid, flat, horizontal surface, on which the mica to be cut is placed. Care must be taken that the knife is sharp and the plates are held close down to the table, otherwise the mica will be crushed at the edge. This cutting-table is used in the case of large sheets of mica, or where it is desired to trim the mineral in straight lines. All portions that are spoilt by striations, buckling, crumpling, cross cleavage, punctures, and other flaws, should be removed.

With regard to stains, some discretion must be exercised. It is a mistake to cut a good plate of mica because a part is spotted. It is better to place it with others of the same kind in a special class of "slightly stained" or "stained" plates. (See p. 288.) It is sometimes recommended, especially in catering for the large English market in this material, that all mica should be cut into rectangular plates with definite dimensions in each direction, usually about an eighth of an inch more than an exact number of inches. Mica in this form can be packed more cheaply and compactly, and the freight is correspondingly less. It also fetches rather better prices, since, as a general rule it can be used with less waste in the manufacture of electrical apparatus, and it is easier to classify and catalogue.

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* This can best be done under water.

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On the other hand, the "trimmings," or waste, has a distinct though small value, and that there are occasions when mica of special shapes is required. Another consideration is that mica, "unmanufactured, or rough-trimmed only,*" is admitted into the United States at a duty of 6 cents per lb. and 20 percent. *ad valorem*, whilst "cut or trimmed" mica is charged 12 cents and the same *ad valorem* duty. As the result of this difference, in the year 1902, the last for which statistics on this point are available, 95·1 per cent. of the mica imported into the United States was "unmanufactured or rough-trimmed," while only 4·9 per cent. of "cut or trimmed mica" was imported. In fact, the latter is practically excluded from the United States market. This prevents the price of mica, cut into exact rectangular pieces, being as much superior to that of untrimmed or rough trimmed mica, as might otherwise be the case.

It is therefore doubtful whether the increased price obtained and the diminished cost of packing, land transport, and sea freight, compensate for the loss in weight if the mica is trimmed at the mine, unless the rates for transport and freight are unusually high. The relative values of the United States of America and United Kingdom markets for mica may be gauged from the fact that the imports into the United Kingdom for 1902 and 1903 were 21,236 and 20,215 cwts., respectively, valued at 74,583*l*. and 88,456*l*.; those into the United States of America for the same years were 17,555 and 16,043 cwts, of the values 84,209*l*. and 81,063*l*. respectively.

All sheets should be split to the thickness of about 1·5 to 3 millimetres (0·062 to 0·125 in.). While there is considerable demand for mica plates of less than 6 square in. (37 square centimetres) in superficial area, the supply is often so large that it scarcely pays to export sizes smaller than this. Where local labour is cheap it is usually better to split them into films or flakes.† A machine has been patented for the manufacture of the latter by alternately bending the plates on rolls and blowing away the films that are detached.

Mica should be packed in wooden cases containing from 50 to 200 lbs. No paper or sacking should be used unless it be necessary for the purpose of separating different qualities or sizes. The plates should be placed one flat on the other till the topmost is slightly above the sides of the box. The lid should then be nailed down so as to compress the plates tightly together and prevent them from moving. The class and size of the mica in each case or part of a case should be exactly stated.

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[*] This is interpreted as including mica trimmed with irregular outlines, or so as to form only *rough* rectangles.

[†] Special knowledge is, however, required in directing these operations if the product is to have a commercial value.

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CHARACTERS OF THE LEADING COMMERCIAL VARIETIES OF MICAS.

Muscovite.

The main divisions correspond, on the whole, to variations in colour. These are again divided into clear, slightly-stained, and stained. The "clear" being quite free from spots, and the "slightly stained" having very few, say one or two stains in 25 square centimetres (4 square in.). Those having more are classed as stained. It has been stated that slightly stained mica is worth about half the price of the "clear," other things being equal; and the stained, one-quarter in the case of small plates and one-eighth in the case of large plates, but no rule can be laid down as the relative value of different qualities is continually changing.

The price per pound increases rapidly with the area, and, especially in the case of plates purchased for electrical purposes, still more with the length. The grades, according to sizes, are approximately as follows: -

Specials over 36 sq. inches (225 sq. cents.)

No. 1 ...	24 to 36 sq. inches	(150 to 225)	sq. cents.
No. 2 ...	15 to 24 „	(94 to 150)	„
No. 3 ...	10 to 15 „	(62 to 94)	„
No. 4 ...	6 to 10 „	(37 to 62)	„
No. 5 ...	3 to 6 „	(19 to 37)	„

For the purpose of ascertaining this area, the mica is placed on a plate ruled in square inches or square centimetres in such a manner as to make it possible to estimate the maximum rectangle it will include.

With the same area long plates usually fetch a better price than those with equal length and breadth, whilst rectangular plates are, as stated above, worth more than those trimmed irregularly. Plates cut to a special required shape also fetch a better price; smaller fragments than those mentioned above are known as scrap mica, and fetch lower prices, which in many cases scarcely cover the freight and other charges.

The chief varieties of muscovite are ruby, from Bengal, Nellore, the Nilgiris, and Brazil; brown, from German East Africa; yellow, from Bengal; green, from Nellore, German East Africa and Brazil; and white mica from Bengal.

The *clear* ruby mica, if it is to fetch the highest prices, should have the following characters:—It should show a faint ruby tint in plates approaching a millimetre (0·04 in.) in thickness, but should be quite clear and transparent. It should be apparently colourless in plates one-tenth of that thickness. The plane of cleavage must be quite true, except perhaps for a very slight and uniform undulation.

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The mica must be perfectly fissile, films 0·01 millimetre (0·004 in.) being produced without much difficulty, and it must be flexible and elastic, in fairly thin laminæ; for instance, a plate 0·1 millimetre (0·004 in.) thick would bend without cracking or appreciable buckling round a cylinder 25 millimetres (1 in.) in diameter, and on being released after half a minute, should regain as nearly as possible its original plane surface. The lustre must be "splendent," that is to say, equal to that of the most highly polished glass.

Slightly stained mica should, except for the few spots due to inter-laminar inclusions, have the same characters as the clear mica.

Stained mica is not only depreciated by being considerably stained with inter-laminar inclusions, but is usually somewhat hydrated, softer and less elastic. It is of considerable value as an insulating material.

The ruby mica of the Nilgiris differs from that from Bengal by the plane of cleavage not being quite so good, though the fissility is greater. Yellow mica is as valuable as ruby mica, but is less common. The green mica from Nellore (Madras) and the green and brown micas from German East Africa are rather deeper in tint, but otherwise similar to the ruby mica of Bengal. The green Nellore mica is, however, more liable to crack when manipulated. All these micas, when sufficiently clear and not too deeply coloured, are in demand where transparency is required, as in lamp chimneys, stove windows, and supports for natural history specimens. The ruby and yellow varieties fetch the highest prices.

White mica is a muscovite from Bengal, which is cloudy, "mealy," or pearly from incipient decomposition or inter-laminar inclusions of gas, and is softer than ruby mica and less valuable but is worth more than stained ruby.

Green hydrated mica is a mica from Nellore, which is softer than the ordinary green mica from that place. It is in some demand for electrical purposes.

Where mica is to form part of a surface subject to moving friction the mica must not be too hard or it will not wear away as fast as the copper conductors beside it, which are subjected to the same friction, nor must it be too soft and wear away more quickly than the copper, for in either case sparking will result. To be of the correct hardness it should be just scratched by the dry thumbnail.* Some of the Bengal micas are well suited for the purpose, but as a rule phlogopites are preferred to muscovites, which are more liable to crack and split.

Immediately after washing, the nail is distinctly softer than when quite dry.

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Phlogopite.

The colourless phlogopite is rarely met with in large plates. The amber coloured phlogopites, on the other hand, are often found in good plates in Cochin (India), Ceylon. Canada, and Brazil; they are in great demand for electrical purposes. The amount of colour is not so important as with muscovites. as they are exclusively used for electrical purposes, for which their insulating qualities, their freedom from cracking and splitting, and consequent uniform wearing render them especially valuable. They are classified into light and dark amber mica and silver amber mica The Brazilian silver amber mica is, in spite of its being rather hard, in much demand for insulating purposes. The plates are, as has been said, sometimes penetrated by cracks, in the neighbourhood of which are the brown transparent stains already referred to, which much diminish the electrical resistance. An amber silver phlogopite is also obtained from the Arctic regions.

The value of phlogopite varies with its size, freedom from flaws or stains, hardness, plane of cleavage and other characters.

Biotites fetch comparatively low prices, as they are not liked for insulating purposes, since they are too hard and have imperfect planes of cleavage.

In the preparation of this article, constant reference has been made to the valuable memoir by Mr T. H. Holland on "The Mica Deposits of India" (*Memoirs of the Geological Survey of India*, Vol. XXXIV., Part II., p. 11, 1902); to the report of Mr. A. K. Coomaraswamy (*Ceylon Administration Reports*, 1903, The Mineral Survey of Ceylon); to Mr H. Kilburn Scott's paper "On the Occurrence of Mica in Brazil and on its Preparation for the Market" (*Transactions of the Institution of Mining and Metallurgy*, Vol. XI., 1902-3); and to particulars received at the Imperial Institute from commercial experts, especially from Mr. E. Davis, who has supplied much valuable information.

THE MANUFACTURE OF COKE IN INDIA.

In an article published in the "Records of the Geological Survey of India," Mr. T. H. Ward discusses the possibility of introducing modern methods of coke-making at certain collieries in India. Coking in India is done at present in open kilns, no attempt being made to recover the by-products, and

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it is only rarely, as in the case of the Anchor ovens introduced by Dr. Saise at Giridih, that any attempt is made to utilise the full heating power of the waste gases. As a consequence, there is a waste of coal due to the consumption of a portion of it in the firing, an undesirable increase of the ash percentage in the coke formed, and a loss of the valuable volatile constituents.

It was pointed out by Major Mahon, in a report dated 1899, on the manufacture of iron and steel, that the coke produced in India was of a very inferior quality, but if care were taken in selecting the most suitable quality of coal, and submitting it to a preliminary washing, coke containing not more than from 12 to 16 per cent. of ash could be produced. In comparison with English coke, even such a quality would be inferior, but it is probably better than the coke now generally produced in India. With the object of determining the value of Giridih coal for coking, two samples were tested in a Simon Carvés oven, with the following results:—

		Sample No. 1 per cent.	Total.	Sample No. 2 per cent.	Total.
Volatile matter.	Ammonia water ...	1·70	21·90	... 0·91	22·78
	Tar...	6·00		... 7·62	
	Gas and loss ...	14·20		... 14·25	
Coke.	Fixed carbon ...	62·97	78·10	... 65·03	77·22
	Ash...	15·13		... 12 19	

These results may also be given in the following form in which they are more readily comparable with the similar information relating to the coking of British coals.

	Sample No. 1 yield per ton.	Sample No. 2 yield per ton.
Gas	9,944 cub. ft.	... 10,231 cub. ft.
Ammonia (Calculated as ammonium sulphate) ...	6·9 lb.	... 7·0 lb.
	26·8 lb.	... 27·4 lb.
Crude benzole	8·57 lb. (0·95 galls.)	... 7·1 lb. (0·8 galls.)

The yield of gas, as might be expected from such highly bituminous coals, compares favourably with that obtained in practice. The yield of ammonia from British coals is, however, seldom less than 20 lb. per ton. The cost of putting down at Giridih either the Coppée "recovery" ovens or the Simon Carvés plant is estimated at 910*l*. and 911*l*. respectively per oven. To deal with 600 tons of coal per week would involve a capital expenditure of 15,483*l*. and 16,400*l*. using these two ovens respectively. The increased profit from the recovery of by-products, and better yield of coke, is estimated at 4,033*l*. per annum, with a production of 20,000 tons of coke from 30,000 tons of coal.

NOTICES OF SOME RECENT UNOFFICIAL PUBLICATIONS.

(All these books have been added to the Imperial Institute Library.)

THE CHEMISTRY OF GAS MANUFACTURE. A Practical Handbook on the Production, Purification and Testing of Illuminating and Fuel Gas, and on the Bye-products of Gas Manufacture. By W. J. Atkinson Butterfield. Third Edition, with illustrations. Volume I. Materials and Processes. Pp. x. + 257. (London: Charles Griffin & Co., 1904.)

This work gives an account of the raw materials used in gas manufacture, their chemical composition and methods of analysis, the production and purification of coal gas, and the manufacture of carburetted water gas and oil gas. A description is given of the various methods employed for enriching or increasing the illuminating power of gas. The book contains a number of illustrations and diagrams.

THE GUIDE TO SOUTH AFRICA. 1904–05. Edited by A. Samler Brown, and G. Gordon Brown, for the Union-Castle Mail Steamship Company, Limited. Pp. 477 + lxiv. (London: Sampson Low, Marston & Co. Twelfth Edition.)

It is stated in the preface that the object of this book is to present in a condensed and easily intelligible form the mass of information necessary to tourists, sportsmen, invalids and settlers.

The work is divided into two parts. The first, or general part, contains notes on matters of immediate importance to the traveller, *e.g.*, outfit, the voyage, hotel accommodation, means and cost of transport, &c.

The climatic conditions of the country are described in detail, and illustrated by maps showing rainfall and climatic zones. The physical features and geology are similarly treated.

The area, population, resources and trade statistics of the several colonies are summarised, and followed by more detailed information on the principal industries and on such topics as immigration, acquisition of land, irrigation, rinderpest, &c. Special attention is given to minerals and mining.

Under the heading of "sport" are practical notes on nature and cost of outfit and equipment, the best starting points, and descriptive information on the principal animals hunted in the country. A chapter on the history of South Africa concludes the first portion of the book.

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The second part is entitled "Routes and Gazetteer," and contains the information required in a guide book, arranged in form suitable for reference, and illustrated by a series of maps.

INDIAN ART AT DELHI, 1903. By Sir George Watt, C.I.E. Indian Government, Calcutta.

This book was issued as the official catalogue of the Art Exhibition which formed part of the Coronation celebration at the Delhi Durbar, and contains a list of the more striking exhibits in each sub-division of the various classes of art products shown, but in addition an account is given of the more noteworthy art industries in India. Under metal wares, to give a few instances, there are notes on lac-colouring practised at Moradabad, Jaipur enamelling on gold, Niello ware from Burmah, and varieties of silver ornamentation from Kashmir. The production of Niello ware is a craft which only survives in one or two localities of Burmah. On pure silver "the pattern is punched, then chased in order to lower the background of the design, and the hollows thus produced are loaded with an amalgam of lead 2 parts, silver 1 part, and copper 1 part. The article is next placed in a charcoal furnace on which fragments of cocoanut shell have been placed to give dense black smoke. It is there retained until the materials fuse and unite with the silver. The flux employed is a mixture of borax, crude sulphate of ammonia, and sulphur. The excess colouring matter is then rubbed off and the silver polished, when the design, in bright silver, appears on a black background. Niello may thus be regarded as a form of enamelling." The methods of damascening and manufacturing encrusted wares are described at some length.

Under Pottery the author supplies information about the various forms of pottery, the substances used in the preparation of varnishes and colour, and other technical details.

A number of examples of wood-carving from different provinces were shown. The leading characteristics of the different styles are analysed, a subject which could only be discussed at considerable length. In some cases interest attaches to the wood which is used. In the Punjab the flat relief is suited to deodar; the deeper carving of the United Provinces and Oudh is effected in rosewood and sal, in Central India the woodwork is crude and gives place to stone-carving, as the "babul" is the only available timber tree. Sandal wood-carving, although practised in many parts of India, is especially typical of Mysore and Southern India, where, in addition to

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relief carving, it is used for figures, but is rarely employed for pierced work such as indicated in the spandril shown; for the deep carving, which is characteristic of Burmah, teak is employed.

In the description of cotton textiles mention is made of the Dacca muslins, of which a fair assortment was shown, and of the figured muslins known as *jamdanis*; silk manufactures include brocades in pure silk, *amrus*, and those called *kinkhabs*, in which gold wire is used as a special weft along with silk or as special warp threads. The chapter on embroidery contains an account of the different stitches employed, discusses network and lace, appliqué work, and gold and silver wire embroidery, a craft quite distinct from the methods of using these metals in the production of *kinkhabs*.

Mr. P. Brown has contributed to the book a number of drawings of craftsmen at work, and has also prepared the account of the loan collections. The large number of illustrations which are included help materially towards a better appreciation of the specimens.

LECTURES ON IRON-FOUNDING by Thomas Turner M.Sc., A.R.S.M., F.I.C. Pp. 132. (London: Charles Griffin & Co., 1904.)

This book is a reprint of five lectures on iron-founding, delivered by the author at the University of Birmingham. The matter is arranged to suit the artizan, and deals briefly with the conditions necessary to produce good iron and sound castings.

Lectures I., II., and III. relate to the manufacture of pig iron from its ores and the constituents of the metal so produced. Lecture IV. deals with the re-melting of the pig iron in cupola and other furnaces preparatory to casting and the making of moulds. Lecture V. concludes the volume with an account of the tests, both chemical and physical, which may be applied to iron in order to judge of its quality or distinguish its defects. The book contains 53 illustrations and diagrams.

NATURE TEACHING; BASED UPON THE GENERAL PRINCIPLES OF AGRICULTURE. For the use of Schools. By Francis Watts, B.Sc. F.I.C., F.C.S., and William G. Freeman, B.Sc., A.R.C.S., F.L.S., Pp. xi. + 193. (London: John Murray, 1904.)

Great interest was aroused in the subject of nature study by the exhibition held in London in July, 1902, and it was then demonstrated how widely appreciation of natural history is

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diffused over the country, the exhibits being of high merit and coming from schools of all classes.

The authors have written this book with the object of shaping the courses of such study both in primary and secondary schools; it is designed to be used as a text-book in the latter, and in the former to assist the teachers in formulating their teaching. The chapters deal with the seed, the root, the stem, the leaf, the soil, plant food and manures, flowers and fruits, weeds, and animal pests; each comprises an explanatory portion followed by full directions for practical work.

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